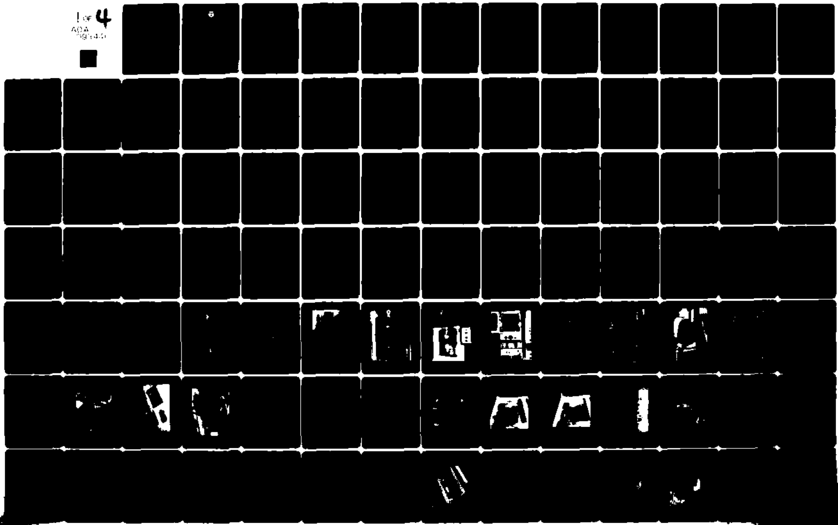
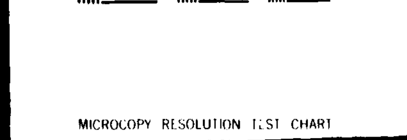
AD-A093 446 GENERAL DYNAMICS CORP POMONA CA POMONA DIV F/G 13/8
MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS.(U)
APR 80 W L MACTURK N66001-79-C-0022
UNCLASSIFIED NAVSEA-MT-S-617-78 NL

1 of 4
ADA
093446



1 OF 4

ADA
093446



LEVEL

NAVSEA MT S-617-78
NOSC TR 560

NAVSEA MT S-617-78
NOSC TR 560

NAVSEA MT S-617-78
NOSC TR 560

12

MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS

A Project of the Manufacturing Technology Program
Naval Sea Systems Command

FINAL REPORT
28 April 1980

Prepared by

WL MacTurk, General Dynamics
(N66001-79-C-0022WJC)

JS Markall, NOSC Coordinator

NAVAL OCEAN SYSTEMS CENTER
SAN DIEGO, CALIFORNIA 92152

NAVAL OCEAN SYSTEMS CENTER, SAN DIEGO, CA 92152

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

SL GUILLE, CAPT, USN
Commander

HL BLOOD
Technical Director

ADMINISTRATIVE INFORMATION

The work in this report was sponsored by the Naval Sea Systems Command as part of the Manufacturing Technology Program. The data discussed in this document were prepared by General Dynamics, Pomona Division, under contract N66001-79-C-0022/WJC

Released by
CL Ward, Head
Design Engineering Division

Under authority of
CD Pierson, Head
Electronics Engineering
and Sciences Department

4

A093 446

NAVAL OCEAN SYSTEMS CENTER
San Diego, California 92152
12 January 1981

NAVSEA MT S-617-78
NOSC TR 560

MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS, A Project of the Manufacturing Technology Program Naval Sea Systems Command, Final Report 28 April 1980, by JS Markall (NOSC) and WL MacTurk (General Dynamics)

LITERATURE CHANGE

Please make the following changes to your copy of NAVSEA MT S-617-78/NOSC TR 560:

1. On page 21, last paragraph, change Table 3-5 to Table 3-6.

2. On page 22, first paragraph, change Table 3-5 to Table 3-6, and in fifth paragraph, change Table 3-6 to Table 3-7.

18 NAVSEA, NC

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19 MT-S-617-78; TR-560

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVSEA MT S-617-78	2. GOVT ACCESSION NO. AD-A093446	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS		5. TYPE OF REPORT & PERIOD COVERED Final rept. March 1979-Febr[redacted]80
		6. PERFORMING ORG. REPORT NUMBER NOSC TR 560
7. AUTHOR(s) William L. MacTurk		8. CONTRACT OR GRANT NUMBER(s) N66001-79-C-0022WJC
9. PERFORMING ORGANIZATION NAME AND ADDRESS General Dynamics Pomona Division 1675 West Mission Blvd., P.O. Box 2507 Pomona, CA 91766		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Sea Systems Command Washington, D.C. 20360		12. REPORT DATE 28 Apr[redacted]980
		13. NUMBER OF PAGES 396
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Ocean Systems Center 271 Catalina Blvd. San Diego, CA 92152		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Engineering Plastic Materials
Injection Molding of Plastics
Electroless Plating of Plastics
Electrical Parameters for Microwave Filters

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The work contained in this report details the activities accomplished from March 1979 to the end of February 1980 by the Advanced Manufacturing Technology Section at General Dynamics, Pomona Division, on a Manufacturing Technology Program for Microwave Components. Specifically, this program deals with the injection molding and plating of a plastic microwave waveguide post filter operating in the S Band region and suitable for use on the Navy Phalanx Ship/Gun System now under production at General Dynamics Pomona.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

147850

JOB

CDRL A003
Code Ident 0543
M-24-6-866

Foreword

This Final Progress Report covers the activities performed from March 1979 through February 1980, under contract N66001-79-C-0022 WJC.

The program was conducted within the Advanced Manufacturing Technology Laboratory at the Pomona Division of General Dynamics. The cognizant responsibility is under Dr. M. L. Charters of Advanced Manufacturing Technology. Mr. William L. MacTurk is the program director and principal investigator. Messrs G. K. Paulitz and C. R. Auletti of Advanced Manufacturing Technology have the technical tasks of the injection molding/tooling and plating portions respectively of this program. Electrical and Environmental Testing is under the direction of Mr. R. M. Haner, Group Engineer of Engineering Design Department 223.

The work has been authorized by the Naval Sea Systems Command, Manufacturing Technology Code SEA 035, Mr. Harry Byron. The contract is being monitored and technical direction provided by the Naval Ocean Systems Center, Code 9243, Mr. John Markall.

PREPARED BY: ______________________
W. L. MacTurk
Senior Manufacturing Development Specialist
Advanced Manufacturing Technology

APPROVED BY: ______________________
M. L. Charters
Chief, Advanced Manufacturing Technology

CDRL A003
Code Ident 0543
M-24-6-866

ABSTRACT

The work contained in this report details the activities accomplished from March 1979 to the end of February 1980 by the Advanced Manufacturing Technology Section at General Dynamics, Pomona Division, on a Manufacturing Technology Program for Microwave Components. Specifically this program deals with the injection molding and plating of a plastic microwave waveguide post filter operating in the S Band region and suitable for use on the Navy Phalanx Ship/Gun System now under production at General Dynamics Pomona.

This extremely low cost lightweight plastic filter has excellent design advantages over the conventional machined metal filter such as VSWR, insertion loss, and attenuation at stop band, in addition to large significant cost factors compared with the machined metal filters of over 20:1.

Since other electrical filters of the same geometry working at different frequency bands in the Phalanx Ship/Gun System are also compatible with this manufacturing development process these filters would also exhibit extremely large cost savings and superior electrical design advantages in comparison with conventional machined metal filters now employed.

This program, sponsored by the Naval Ocean Systems Center, San Diego, California, under contract N66001-79-C-0022 WJC, enabled the transition from a development phase to a production-ready manufacturing process whereby low cost, lightweight, injection molded microwave filters were produced with high production yields commensurate with high design reliability and performance.

This final report also contains the test plan which was assiduously followed during the course of the program and the results appear as appendices at the end of the report with the appropriate organization group that conducted the tests designated.

ABSTRACT (Continued)

A Development Process Specification (D.P.S.) detailing the manufacturing steps pursued in the construction of these microwave filters is also appended to this final report along with vendor information as to the materials employed in the fabrication of the filters.

Engineering drawings and tool drawings of the filter design and fabrication are also included in this final report.

CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

CDRL A003
Code Ident 0543
M-24-6-866

1.0 OBJECTIVE

To establish, demonstrate, and document a manufacturing process specifically for fabricating plated microwave injection molded post waveguide filters operating in the S band region. The filter in question is a 13 post comb filter injection molded from a polyester/glass filled thermoplastic called Valox 420 SEO manufactured by General Electric.

This process shall be commensurate with production scale techniques and tooling. The resultant filters will be suitable for use with land or sea based military radar systems and also on missile radar and aircraft radar systems.

These injection molded filters will exhibit superior electrical characteristics to the conventional metal machined filters with cost reductions greater than 20:1.

2.0 INTRODUCTION

Over the past several years much of the IRAD activity pursued by the Advanced Manufacturing Technology Section at General Dynamics Pomona Division has been in the field of plastic injection molded microwave componentry. Here high strength, high temperature injection molded plastics have been utilized to produce precision microwave components at a fraction of the cost of conventional metal componentry, and in many cases superior electrical characteristics and, as a consequence, superior design reliability are achieved. Design repeatability has also been enhanced by these automated processes since machine operator error has been removed.

Four patents have been issued to General Dynamics, Pomona Division over the past four years on plastic molded microwave horns, filters, and antennas. They are: 3,896,545, Molded Waveguide Filter with Integral Tuning Posts; 3,955,161, Molded Waveguide Filters with Integral Tuning Posts; 3,897,294, Forming a Parabolic Antenna; and 3,985,851, Method of Forming a Feed Horn.

The Phalanx CIWS System has incorporated an injection molded microwave window lens into the production contract, with a series of four microwave filters of differing wavelengths also being proposed by the Engineering Group for acceptance into the Phalanx CIWS production contract, after the initial successes by Advanced Manufacturing Technology on plated microwave filters exhibiting superior electrical characteristics at cost savings greater than 20:1 over conventional machined metal filters.

Machined metal filters of this type due to stringent dimensional tolerances and complexity of manufacture do not afford production yields and if costly machining, dip brazing, plating and assembly operations attendant with large capital equipment outlays are to be avoided it is mandatory that the highly automated injection molded microwave filter be employed.

To this end the program sponsored by N.O.S.C San Diego, California and contained in this report will show the feasibility of this type of microwave plastic component and its acceptance into the Navy Phalanx CIWS.

3.0 ENGINEERING APPROACH AND RESULTS

3.1 Machined Metal Microwave Filters

Conventional machined metal waveguide post filters by their nature have extremely high attendant cost factors and are difficult to produce.

Large capital outlays are required for machining and dip brazing metal waveguide filters, and with the stringent dimensional tolerances which must be met with these microwave components an inherently large scrap rate results.

Repeated operator errors in machining these metal filters and the ensuing complex dip brazing and assembly operations imply a condition of non-uniformity of dimension between filters and tolerance error build-up between the tuning posts of each filter. This in turn leads to poor electrical filtering or failure at the operational level. This has been evidenced in the S band filter contained in the body of this report where electrical specifications such as insertion loss, VSWR, and stop band attenuation could not be met and had to be increased in order to produce a machined metal filter within the specified pass band.

The current standard approach in industry for fabricating microwave post filters is the conventional method of machining metals such as aluminum and copper and the utilization of dip or silver brazing of the metal posts into the machined metal waveguide cavity or in some cases dip or silver brazing the posts into the filter cap. The filter cap is then machined with attachment holes being drilled through the cap and mating with threaded holes in the waveguide cavity walls. Tuning screws directly over or under the tuning posts depending on whether the posts are in the filter cap or waveguide cavity allow tuning of the filters by adjusting the tuning screw into the waveguide cavity and so increasing or decreasing the capacitive air gap between the post and tuning screw.

Since most post metal filters are fabricated from aluminum due to weight reasons, these filters to prevent oxidation with time are both copper and gold plated electrolytically. These plating operations because of the complex physical geometry of the filters enhance out of tolerance conditions due to non-uniform plating thickness build-up caused by sharp corners in the waveguide cavities, tuning post extremities, and tuning screw cavities. This in addition to the stringent dimensional tolerances (0.003" to 0.0005")

between post separation, post height, post diameter, and post perpendicularity to waveguide 'a' and 'b' dimensions all exhibit a precision which is difficult to achieve by conventional machining practices.

3.1.1 Electrical Considerations

The design of microwave post filters is based on electrically coupling arrays of circular rods located between parallel ground planes. These rods are made to resonate up to the mutual capacitances (C_m) between rods and the self-capacitance (Cg) of each rod and ground. To provide the proper frequency response and band width desired, post diameter and post separation are made to vary along the center line of the b-plane of the waveguide cavity. The resultant small differences in mutual and self-capacitances (pico-farads) between rods and between each rod and ground can be directly related to precise physical dimensions.

Figure 3-1 shows the electrical configuration of four electrically coupled circular cylindrical rods between the parallel ground planes of a waveguide body. The circular rods have a diameter, d, and are spaced periodically at a distance, C. The ground planes are separated at a distance, b. The spacing between adjacent rod surfaces is denoted by a s and is given by s = c - d with each rod having some inductance value L.

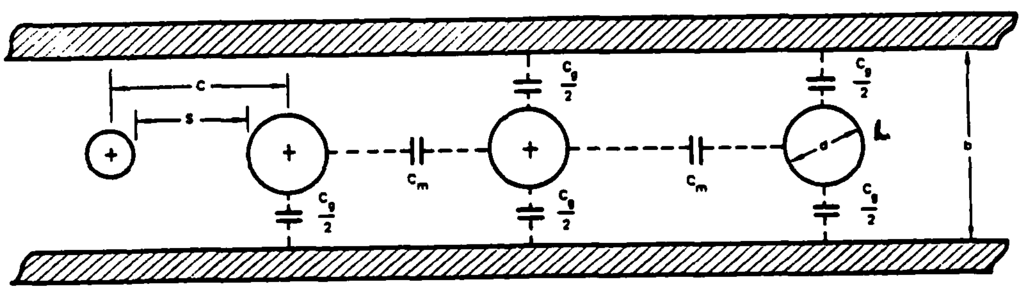


Figure 3-1 Electrical Configuration of Circular Rods

Since small changes in the total static capacitance between neighboring rods (sum of mutual and self-capacitances) result in large frequency variations, it is mandatory that physical dimensioning of the rod diameters and spacings which directly relate to these capacitances be precisely controlled.

3.1.1.1 Tuning

In practice it has been extremely difficult to machine metal microwave filters and provide the stringent electrical performance requirements desired. To provide some degree of control over bandpass, attenuation, and insertion loss, tuning slugs are positioned in the filter cap directly over each tuning post, the post height being such that a constant air gap between post height and the base of the filter cap is effected. The tuning slug is then adjusted into this air gap to effect an increasing or decreasing air capacitance as the need may be, and so control to some extent the mutual and self-capacitances of successive coupled rods.

This has proved satisfactory to some degree, although tuning times have been excessive. For the S13 filter in question, tuning the filter has taken in excess of 6 hours and in some cases, due to out-of-tolerance machining, it can not be tuned.

The S13 metal filter discussed in this program has 13 tuning screws. Each tuning screw has to be precisely adjusted by hand and the 13 tuning screws have to be set and reset as adjustments are made between successive pairs of rods in order to produce the proper bandpass and frequency response over a large band of frequencies.

3.1.2 Metal Filter Costs

A cost analysis conducted some years ago on an S13 metal filter showed a machine time in excess of 36 hours. Assembly time was in excess of 16 hours, and the problem encountered in repeatability of dimensional tolerances due to operator error resulted in a large scrap rate (over 30 percent).

Comparing these costs with that of an injection molded plastic filter, an operator using a single cavity mold can produce 40 filters in an 8-hour work day. This is significant when it is also considered that repeatability of dimensional tolerances is easily achieved and, unlike conventional machined filters, operator error is entirely eliminated.

Figure 3-2 shows an S13 machined metal filter after final assembly.

3.2 Selection of an Injection Molding Thermoplastic

As referenced in the Test Plan, Appendix A the program began with examining the physical properties of the plastic selected after a thorough comparison had been made with other injection molding thermoplastics.

The Test Plan was the outline used in the compilation of the body of this report and should be consulted as to program development and time scheduling.

Three thermoplastics that were initially attractive as candidates for microwave filters were: Borg Warner's plating grade ABS Cycolac EP 3510 for its ease of plating and moldability; General Electric's 20% glass filled polycarbonate Lexan 3412 for its low coefficient of thermal expansion (1.49×10^{-5} in/in/^{o}F), and Valox, which also possessed a low coefficient of thermal expansion (3.10×10^{-5} in/in/^{o}F) and thermal conductivity (1.3 BTU/hr/ft^2/^{o}F/in). A summary of the plastics' thermal and mechanical properties is shown in Table 3-1.

Despite its ease of plating and high copper adhesion Borg Warner's ABS was found to be unsatisfactory. This was due to its relatively high coefficient of linear thermal expansion (see Table 3-1) which led to longitudinal cracking of the electroless copper when subjected to thermal cycling. Since dimensional stability is critical to the fabrication of the filter, it was felt that the ABS parts would exceed dimensional tolerances.

Though Lexan easily passed the dimensional stability requirement, its surface was found to be difficult to "wet" and all adhesion values were well under one pound pull per inch width. The poor copper adhesion led to numerous blisters on plated Lexan parts.

Like Lexan, Valox easily met dimensional tolerance requirements, but its surface unlike Lexan's was easily wettable, which allowed for even etching action, and ultimately far greater copper adhesion.

Copper-plated Valox parts passed the thermal cycling temperatures, with no longitudinal cracking in the plating. This was due to the lower coefficient of thermal expansion (as compared to ABS) brought about by the presence of glass fibers in the polyester resin.

3.2.1 Coefficient of Thermal Expansion and Thermal Conductivity of Injection Molded Plastics

In intricate molded shapes such as the microwave filter under discussion two important characteristics should be observed during the molding phase. These are the coefficient of thermal expansion of the plastic (α) and the thermal conductivity factor (k).

Coefficients of thermal expansion should be as low as possible, and thermal conduction be as high as practical, consistent with good design practice. Complex injection molded shapes with high thermal expansion coefficients and low thermal conductivities exhibit considerable "dimpling" and "sinking" due to poor heat conduction and high shrinkage through the thicker portion of the mold during the molding phase. Good heat conduction through the plastic to the cold surfaces of the tooling mold must be accomplished uniformly and quickly if "sinks" are to be prevented, especially under the high pressures involved.

Examples of these effects are numerous and Figure 3-3 shows this condition for ABS plastic (Cycolac). Figure 3-4 shows the smooth, uniform appearance of a polyester/glass (Valox) molded part at the same location.

Table 3-1 is self-explanatory and defines the large differences in the α and k factors between ABS platable-grade injection molded plastic and injection molded polyester/glass.

Figure 3-3 also exhibits carbonizing at the top of the output post. This condition is enhanced by the low thermal conductivity of the ABS plastic although the major cause is plastic "burning" due to extremely hot air entrapment and slow air escape in that area.

3.2.2 Valox 420 SEO Properties

Physical and mechanical properties of Valox 420 SEO are excellent. The heat deflection temperature is very high and is rated at 415^{o}F. Water absorption is very low and a waveguide filter immersed in water at room temperature for 24 hours showed an increase in weight of only 0.08 percent. At an operating temperature of 160^{o}F, the maximum temperature the filters would experience, the flexural modulus of the Valox would be greater than 5.7×10^5 psi and the tensile strength in excess of 10.6×10^3 psi.

For these reasons and others stated previously this injection molded plastic was accepted for fabrication of the S13 microwave filter.

3.3 Mechanical Properties of Valox 420 SEO

3.3.1 Sample Size Selection

The program began with the design and fabrication of the molds for tensile strength, compressive strength, and flexural modulus.

The mold for the tensile strength was made in accordance with ASTM D638-71a utilizing a type V sample size.

Type V represents the smallest sample and is 0.125" thick, 0.125" wide, and 2.5" long. This smaller size was selected for all cases because it is superior in moldability. This will result in a more homogeneous density and thus a true sample of the material.

A larger sample size would develop premature crystallization and perhaps voids. For the compressive strength test a sample size of 0.125" thick, 0.50" wide, and 1.0" long was selected from paragraph 5-2 of ASTM D695. For the flexural modulus test a sample size of 0.125" thick, 0.50" wide, and 2.5" long was selected because of its compatibility with the compressive sample in thickness and width, and acceptability with ASTM D790. Both samples were cut from parts made from a 0.125" by 0.5" by 3.0" mold. This was done to reduce tooling costs on the sample molds.

Both the tensile mold and the common mold used for the compressive strength and flexural modulus tests after fabrication were used to mold the specimens required for the comprehensive tests which followed.

Five test coupons each were fabricated for the three tests specified above. Figures 3-5, 3-6 show two specimens in the Instron Testing Machine ready for tensile strength measurements. Figure 3-7 depicts the chart drive of the Instron Universal Testing Machine.

3.3.2 Tensile Strength

As stated in Section II-B, 1 of the Test Plan tensile strength of the five injection molded Valox coupons should be greater than 16,000 psi.

Table 3-2 shows the tensile strength on five molded coupons all well above the test acceptance level, and from the table the mathematics derived for tensile strength, sampling, and standard deviation.

$A = W \mathrm{x} D$ where A = area (in^2); W = Width (in); D = Depth (in)

$$\text{Stress} = \text{Force}/A$$

$$\bar{X} = (X^1 + X^2 \cdots X^N)/N$$

$$\text{Std.Dev.} = \sqrt{\frac{\Sigma X^2 - N\bar{X}^2}{N-1}}$$

Using the data for sample 0

$$A = 0.129\text{"} \times 0.121\text{"} = .0156 \text{ in}^2$$

$$\text{Stress} = 275 \text{ lbs}/0.0156 \text{ in}^2 = 1.76 \times 10^4 \text{ psi}$$

and for the total sampling,

$$\bar{X} = 1.77 \times 10^4 \text{ psi}$$

$$\text{Std. Dev.} = \sqrt{\frac{(1.76 \times 10^4)^2 + (1.71 \times 10^4)^2 \cdots -5(1.77 \times 10^4)^2}{4}}$$

$$= 4.89 \times 10^2 \text{ psi}$$

Two coupons, numbers 4 and 5, were discarded since breakage occurred outside the predetermined gage marks. (See ASTM D 638 paragraph 7.3.)

Appendix B contains the chart graph data taken from the Instron Tensilometer.

3.3.3 Compressive Strength

Table 3-3 delineates compressive strength sampling on six test coupons. Test acceptance level was 18,000 psi as indicated in the Test Plan and again all sample coupons well exceeded the test specification. As in the tensile strength measurements the average value and the standard deviation value computed as required by ASTM D638-71a paragraph 10.6 and 10.7 were derived as follows:

$A = W \times D$ where A = Area (in^2); W = Width (in); and D = Depth (in)

$$\text{Stress} = \text{Force}/A$$

$$\bar{X} = (X_1 + X_2 + \cdots X_N)/N$$

$$\text{Std. Dev.} = \sqrt{\frac{\Sigma X^2 - N\bar{X}^2}{N-1}}$$

Using the data for sample 1,

$$A = 0.491 \times 0.123 = 6.04 \times 10^{-2} \text{ in}^2$$

$$\text{Stress} = 1235 \text{ lbs}/6.04 \times 10^{-2} \text{in}^2 = 2.05 \times 10^4 \text{ psi}$$

and for the total sampling,

$$\bar{X} = 2.18 \times 10^4 \text{ psi}$$

$$\text{Std. Dev.} = \sqrt{\frac{(2.05 \times 10^4)^2 + (2.11 \times 10^4)^2 \cdots -(6\ (2.18 \times 10^4)^2)}{5}}$$

$$= 9.83 \times 10^2 \text{ psi}$$

Appendix B lists the chart graph data.

3.3.4 Flexural Modulus

The flexural modulus samples, like the tensile and compressive samples, were made intentionally small. They were selected from ASTM-D790, Method I, and had a 0.500" width, 0.125" depth, and 2.5" length. Five samples were molded by Manufacturing Technology and tested by Department 27, Quality Assurance Group.

Table 3-4 gives the sample data and test results.

Appended below is the mathematics deriving the required standard deviation and the flexural modulus value for sample number 1.

where,

$$S = \frac{L^3 P}{48IE} \quad \text{and } I = \frac{Bd^3}{12}$$

$$E = \frac{L^3 \left(\frac{P}{S} \right)}{4\ bd^3}$$

P/S = Slope at tangent to load deflection curve.

$$\bar{X} = (X_1 + X_2 + X_3 \cdots X_N)/N$$

$$\text{Std. Dev.} = \sqrt{\frac{\Sigma X^2 - N\bar{X}^2}{N-1}}$$

using the data for sample 1,

$$E = \frac{(2in^3) \times (500\ lb/in)}{4\ (0.489") \times (0.122)^3} = 1.13 \times 10^6\ psi$$

and for the total sampling,

$$\bar{X} = 1.17 \times 10^6\ psi$$

$$\text{Std. Dev.} = \sqrt{\frac{(1.13 \times 10^6)^2 + (1.19 \times 10^6)^2 \cdots - 5(1.17 \times 10^6)^2}{4}}$$

$$= 3.35 \times 10^4\ psi$$

Figure 3-8 specimen A shows a flexural modulus sample after testing.

3.4 Thermal Properties of Valox 420 SEO

To verify the vendor's (General Electric) thermal properties two pieces of test equipment were designed and built. These were (a) a thermal chamber to determine the thermal conductivity of the Valox 420 SEO plastic and (b) a controlled temperature water chamber containing the specimen to verify the thermal expansion of Valox 420 SEO.

3.4.1 Thermal Chamber and Heat Source

An insulated chamber was fabricated from 2 lb/ft^3 polyurethane foam molded with a cylindrical hollow core to accept the aluminum heat sources. Thickness of foam insulation including the cover was approximately 3".

The aluminum heat reservoir was a solid aluminum cylinder 4.25" in diameter and 18" long of 6061 alloy. The mass of this cylinder was 19.31 lbs or 8.76 Kg. Figure 3-9 shows the heat source and insulation. The mating surface at the end of the cylinder to which the plastic test sample was attached was machined flat and polished to a 6 μ inch RMS finish.

The plastic sample was attached by four screws around the periphery of the aluminum cylinder. Sample thickness was 0.184" with a diameter of 4.25". The thermocouple monitoring the outer face of the plastic sample is retained by flexible low density foam of low thermal conductivity, while the heat reservoir thermocouple is retained by a small hole drilled into the aluminum heat source surface. Figure 3-10 depicts this assembly. The heat reservoir is subjected to an oven temperature for 8 hours before being placed in the thermal chamber. No temperature drop of this heat reservoir has been observed over a period of two hours. Duration of the thermal conductivity test will be no greater than ten minutes.

3.4.1.1 Thermal Conductivity of Valox 420 SEO

An injection molded circular plastic sample of Valox 420 SEO, 4.25" in diameter and 0.184" in thickness, was mounted to the end of a solid aluminum cylinder 4.25" in diameter and 18" in length by four screws, the aluminum cylinder acting as the heat source and being encased in an insulated chamber of molded 2 lb/ft^3 polyurethane foam.

Two thermocouples were attached to the assembly, one thermocouple monitoring the aluminum heat source and being read by a precise digital thermometer, and the other monitoring the outer surface of the plastic sample and being read on an X-Y recorder. Figure 3-11 shows the test equipment used. Results were as follows;

$$Q = \frac{MC\Delta t}{\Delta \theta} = \frac{0.148 \times 0.55 \times 82}{0.117} = 56.77 \text{ BTU's/hr}$$

and $$K = \frac{QX}{At} = \frac{56.77 \times 0.184}{0.098} = 1.3 \text{ BTU/hr/ft}^2/\text{F}^\circ/\text{in}$$

where Q = BTU/hr

M = mass/lbs of sample specimen = 0.148 lbs

C = specific heat of Valox 420 SEO = 0.55

Δt = temperature difference between sample conducting surfaces (i.e. $t_1 - t_2$)$^\circ$F

$\Delta \theta$ = Time to reach temperature difference - Hours = 0.117 Hrs.

X = sample thickness - inches = 0.184"

A = area of sample part - feet^2 = 0.098 Ft^2

Vendor data sheet specifies the thermal conductivity of Valox 420 SEO as 1.3 BTU/hr/ft^2/F$^\circ$/in.

3.4.1.2 Thermal Expansion Apparatus

The coefficient of thermal expansion of Valox 420 SEO was measured in the range from -40°F to 160°F using a liquid cooled (alcohol) and water heated jacketed sample fixture.

The apparatus consisted of a temperature controlled heating or cooling source, a variable speed pump and a jacketed sample fixture. The fixture consisted of a 1.6" diameter (ID) aluminum tube, 5" long with an input and output fluid port at each end of the tube. The sample dimensions were 5.5" x 0.30" x 0.44" with the sample protruding from each end of the tube in such a manner as to be restrained externally at one end and the expansion of the sample measured at the other end with a precision dial indicator. The tube ends were sealed with silicon rubber which does not inhibit the expansion of the Valox test sample. The temperature control-assembly was mounted in a foam insulated box to reduce convective heat losses. Figure 3-12 shows the test apparatus in the cooling mode.

3.4.1.2.1 Thermal Expansion of Valox 420 SEO

The starting temperature for the reference measurement was 76.5°F. The initial length of the part was checked and recorded at 5.628". The part was then held secure on one end by an anchor plate and a Brown and Sharp dial indicator was set to 0.0000" on the other end. Hot water was pumped through the chamber and maintained at 30°C (86.8°F) for 15 minutes. The dial indicator showed the expansion to be 0.0008".

From the expression $\Delta L = \alpha L \Delta t$, the experimental coefficient of thermal expansion is calculated.

Where ΔL = total change in length

α = coefficient of linear expansion

L = starting length

Δt = temperature change

Using the experimental data,

$$\alpha = \frac{8 \times 10^{-4}}{5.628" \times (86.8^{\circ}F - 76.5^{\circ}F)}$$

$$= 1.38 \times 10^{-5} \text{ in/in/}^{\circ}\text{F.}$$

Experimental uncertainty utilizing this apparatus is derived theoretically by taking the partial derivative of the equation for $\alpha = \Delta L / L \Delta t$. The partial of each variable is interpreted as the uncertainty in the measured value of that quantity.

$$\partial\alpha = \frac{L\Delta t\, \partial(\Delta L) - \Delta L(L\Delta t\, \partial(\Delta t) - L\Delta t\, \partial L)}{(L\Delta t)^2}$$

$$= \frac{\partial(\Delta L) - \Delta L(\partial(\Delta t) + \partial L)}{L\Delta t}$$

Where,

$\partial(\Delta t)$ = 0.1°F

$\partial(\Delta L)$ = 10^{-4} in

∂L = 10^{-3} in

Δt = 10.3°F

ΔL = 0.8×10^{-3} in

L = 5.628 in

Evaluating, the experimental uncertainty of the values of α is no better than 3.3×10^{-7} in/in/^{o}F. Therefore, α is 1.38 ± 10^{-5} in/in/^{o}F for the temperature range of 22^{o}C to 30^{o}C.

A similar experiment using an alcohol bath for the temperature range of -30^{o}C to 22^{o}C derived an experimental value for α of $1.35 \pm 0.15 \times 10^{-5}$ in/in/^{o}F.

The vendor's specified value for α in the flow direction is 1.4×10^{-5} in/in/^{o}F. All values determined by this test apparatus agree closely with the vendor values.

3.5 Electroless Copper Plating of Valox 420 SEO

Excellent progress was made in the areas of vapor honing, plating process development, and copper adhesion during the first quarter of this program. Figure 3-13 shows the injection molding machine from which the plating samples were injection molded.

3.5.1 Vapor Honing

The vapor honing equipment consists of a venturi feed air spray gun with a ceramic nozzle, an aluminum spray booth and a three gallon reservoir with a variable speed rotary mixer. The apparatus is depicted in Figure 3-14.

The most efficient concentration of vapor honing grit contained in the slurry was determined to be twenty percent by weight. Grit sizes of #325, #325/150 blend, and #220 were utilized to determine which yields the greatest adhesion values.

3.5.2 Plating Apparatus

A Masterflex tube pump and variable speed controller is being used to circulate the plating solution through a double walled nylon filter bag packed with glass wool. The tube pump and plating set-up are shown in Figures 3-15 and 3-16 respectively.

The tube pump is unique because Shipley's CP-70 electroless copper will deposit copper on the internal parts of conventional filtration systems, rendering them useless. The plating solution never comes into contact with the tube pump as the solution is self-contained in high temperature Tygon tubing. Tygon is also resistant to strong acids and alkalis. The variable speed pump

is capable of pumping from one to fifty gallons per hour.

3.5.3 Plating Conditions for Valox

The plating bath is air agitated as well as being circulated with the filtration pump. Air agitation prevents hydrogen gas bubbles, generated by the reduction of copper, from adhering to the surface of the part and causing voids in the plating to develop.

Two vendor supplied palladium catalysts were experimented with to activate the Valox substrate prior to metallization. The catalysts contain colloidal palladium. The difference between the two is in the size of the colloid. A smaller colloid provides more nucleation sites for the copper, and thus greater adhesion and a more uniform coverage.

The finer colloid is also operated hot, 110^{o}F, providing a greater mobility of the palladium and a more even coverage. The large colloid is run at room temperature and frequently decomposes due to the reluctance of the larger particles to remain in suspension. The small colloid, Shipley's Cataposit 44, has also increased the copper adhesion to the Valox substrate.

3.5.4 Copper Adhesion

Copper adhesion is determined quantitatively by measuring the pounds of force required to peel the copper off the Valox substrate. Peel tests were accomplished in the following manner: First tensile bar test specimens were injection molded and vapor honed thoroughly. After 1-2 mils of Shipley CP-70 heavy build electroless copper were deposited on the samples, the specimens had four 1/8 inch peel test patterns photoengraved on the copper surface. After etching the peel test patterns were pulled by the Instron Universal Testing Machine Model No. TTD. Multiplying the machine reading by eight yielded a value with dimensions of pounds pull per inch width.

Though vapor honing is critical for good copper adhesion, it alone did not prepare the surface adequately; an average value of 0.80 lbs per inch width of copper adhesion was obtained for a specimen treated solely by vapor honing. Chemical etchants were needed to further increase copper adhesion.

Two types of etchants were desirable: One to degrade the polyester and another to attack the glass fibers imbedded in the polyester resin. Polyester is attacked by strong acids and strong

alkalis and tests were developed to determine which reagent yielded superior attack results.

The first test run was to obtain the percentage weight loss of the tensile bar. If a reagent was effectively attacking the polyester, a decrease in the total weight of the specimen would be observed. Magnetically stirred, four liter baths of 20% (by weight) NaOH, 50% (by volume) HNO_3, and 20% H_3PO_4 - 10% H_2SO_4 in saturated H_2CrO_4 were prepared. After subjecting samples to various times in the baths, only specimens treated in NaOH showed no appreciable weight loss. The samples subjected to the H_3PO_4-H_2SO_4-H_2CrO_4 bath could not be entirely activated by the palladium catalyst due to a powdery film. This film could not be removed by ultrasonic cleaning, lengthy rinsing cycles, or chemical treatment. Mechanical removal of this film would not be feasible on the comb filter, so 50% HNO_3 was chosen to etch the polyester.

Ammonium bifluoride ($NH_4F \cdot HF$) and hydrofluoric acid (HF) were the two reagents considered as the etchants for the glass fibers. A 10% (by volume) solution of HF was chosen because of its much faster reaction rate in attacking the glass.

The next task was to determine the length of time in each etchant a part should be exposed. A test was set-up comparing time in etching baths versus peel strength. Samples were subjected to various times in the 50% HNO_3 and 10% HF baths, after spending ten minutes in the cleaner/conditioner and then plated. This data is summarized on Figure 3-17. The time where a maximum occurred is where the most effective etching took place.

The maximums occurred at five minutes in the HNO_3 bath and between five and ten minutes in the HF bath.

Additional etch time versus peel strength tests were run combining the HNO_3 and HF etchants. A five minute etch in the HNO_3 bath was held constant for all tests because of the discrete maximum obtained at five minutes on Figure 3-17. Etch time in HF was varied from five to sixty minutes, the samples were then plated and pulled. These results are summarized on Figure 3-18. A maximum was observed between five and ten minutes, coinciding with the maximum on Figure 3-17 where HF was the sole etchant. From this it was concluded that etches of five minutes in HNO3 and seven and one half minutes in HF are the most effective etches for Valox before plating, yielding up to three pounds per inch peel strength.

This conclusion was reinforced by peel strength versus percent weight loss tests shown on Figure 3-19. The weight losses were recorded for all combined HNO_3 and HF etches, and then plotted against their respective peel strengths. The range of most efficient percent weight losses occurred between 0.15% and 0.35%. The weight loss for a 5 minute HNO_3/10 minute HF etch was 0.24%, which fell near the middle of the maximum range.

3.5.4.1 Plating Adhesion of Test Coupons

Figure 3-20 depicts the sequence of operations in preparing a test coupon for peel testing, they are:

A. Injection Molded Test Coupon.
B. Plated Test Coupon.
C. Photoengraved Test Coupon.
D. Etched Test Coupon.

The etched test coupon was then set up on the Instron Universal Testing Machine as shown in Figure 3-21. The crosshead speed of the Instron was set at 2 inches per minute as called out in Mil-Std-P-55617. Figure 3-22 shows the peel test being performed on one of the Valox/copper test coupons. The average peel strength for three test coupons was 2.9 pounds per inch width. These adhesion values meet the requirements of the Test Plan Section II-C-1 and the test results are documented in Quality Assurance Report 225952. See Appendix C.

3.5.5 Copper Thickness and Uniformity

Six test specimens were plated for microsectioning and analysis by the Quality Assurance Group, Dept. 27. The uniformity of plating was verified by measuring the thickness of copper at the top, middle, and bottom of the coupon. Figure 3-23 shows a typical microsection of a plated test coupon. The six coupons met the requirements of Test Plan Sections II-C-2, and II-C-3 which state that the copper thickness including gold flash shall be 0.0008" ± 0.0002" and shall not vary above or below the dimension and tolerance at any given point on the test coupon. The results are tabulated in Quality Assurance Report R 225978. See Appendix C.

3.5.6 Surface Finish of Test Coupons

Six additional test specimens were plated for surface finish measurements to be recorded by the Quality Assurance Group. The plated test coupons were inspected on a Taylor Hobson Talysurf 10

Profilometer. Surface finish on all the plated test coupons met the 63√ as called out in the Test Plan Section II-C-4. The test results are contained in Appendix C and Table 3-8.

3.5.7 Plating Integrity After Thermal Shock

A CO_2 bottle was connected to a calibrated thermal chamber, the chamber containing an automatic sensor and solenoid control to maintain the low temperature extreme required (-40°F). The chamber was also equipped with high temperature controls when manually set to the temperature desired (+160°F). Attached to the chamber with an iron/constantan thermocouple was a precision digital thermometer (± 2°F, - 60°F to 500°F).

Temperature cycling was recorded on a calibrated thermal graph recorder also attached to the chamber. Testing involved temperature cycling the six electroless copper plated Valox samples from -40°F to +160°F for ten cycles using the time durations called out in Mil-Std 202D, Table 107-1.

$$\left.\begin{array}{l}\text{-40°F for 30 minutes}\\ \text{Room Temp for 5 minutes max.}\\ \text{+160°F for 30 minutes}\end{array}\right\}\text{1 Cycle}$$

Time to cycle between -40°F and +160°F was less than 5 minutes and conversely the time duration to cycle between +160°F to -40°F was less than 5 minutes. Figure 3-24 shows the samples in the thermal chamber and Figure 3-25 the entire test set-up.

The six test coupons were examined by the Quality Assurance Group Dept. 27 for delamination and blistering, as per Test Plan Section II-D-1. No delamination or blistering occurred from the harsh thermal cycling. The test results are documented in Quality Assurance Report R272259. See Appendix D.

3.5.8 Plating Process Development

With the proper etchants and times of immersion in each bath now obtained, a total metallizing procedure for Valox has been finalized. The procedure is outlined in Table 3-5.

3.6 Injection Molding Development

3.6.1 Prototype Mold

Using an existing S13 prototype mold, which had been used in prior years to demonstrate the feasibility of injection molding this complex electrical filter, Advanced Manufacturing Technology examined solutions to problems encountered previously. The areas of endeavor were, 1) the elimination of warpage and 2) an examination of the thermal cycle effects on plastic shrinkage. The data gained from these experiments was then used in the production mold design.

3.6.1.1 Warpage

The warpage, caused by unequal shrinkage of the Valox filters, was due to the anisotropic characteristics of the glass filled plastic. The gating of the prototype mold was altered to demonstrate the warpage reduction through proper gate location. The prototype waveguide cavity mold, shown in Figure 3-26, was altered with a second gate, such that the plastic flow along the B plane was balanced horizontally. Molded parts exhibited 0.000" warpage longitudinally in the B plane and 0.010" longitudinally in the A plane due to the vertical flow imbalance. From this data it was decided to gate the production mold cavity with two gates at the edge thereby balancing plastic flow in all planes. This gate style and others are illustrated in Figure 3-27.

3.6.1.2 Shrinkage at Elevated Temperatures

Design requirements for the S13 filter included the ability of the part to withstand a non-operating temperature range from -40°F to +160°F with no degradation of the electrical requirements as called out in section II-I-1,2 of the Test Plan. For this reason the prototype mold was used to evaluate the creep or long term shrinkage at elevated temperatures. Molded samples were held at room temperature for one month, six hours at 110°F to simulate plating, and 40 hours at 160°F to simulate a non-operating storage temperature. Measurements conducted during and in between these steps showed no creepage at room temperature. The plating creepage was 0.002 in./in. in the cross-flow direction and 0.0002 in./in. in the flow direction. The resulting 160°F creepage was 0.004 in./in. in the cross-flow direction and 0.0000 in./in. in the flow direction. However all 160°F creep occurred in the first 16 hours with no measurable change in the last 24 hours. The creep differentials were largely due to glass fiber orientation within the plastic which occur with plastic flow into the mold cavity.

3.6.1.3 One Piece Post Cavity Mold

The feasibility of a one piece post cavity was demonstrated in an effort to eliminate the tuning post flash and the resulting poor physical tolerances, both caused by the spreading of the two piece post cavity mold. Here a "Valox" ejector was used to eject the molded part out of the mold shown in Figure 3-28. Previously the two cavity halves were unbolted and separated allowing part removal. Because of this successful demonstration the production post cavity was designed as a single unit with 0° post taper.

3.6.2 S13 Production Mold Design - Initial Phase

The production molds, although similar to the prototype molds in their basic design, incorporated closer tolerances and were far more durable to help withstand the "Valox" glass abrasive qualities under high injection mold pressures. Other mold differences included: molded in end-caps, edge gating for better flow characteristics, and as stated before a one piece post cavity.

Filter production in an on-going Ship/Gun Program production was intended to be the end use of the new molds and for this reason a Martensitic 440C stainless steel was chosen as the mold material. 440C combines a high abrasion resistance, resistance to corrosion, medium machinability, and medium resistance to softening. It was hardened to a Rockwell C of 56 and polished to a 10 finish. Coefficient of thermal expansion of this stainless steel is 5.6×10^{-6} in./in. $^{\circ}$F.

Because of the stringent tolerances in the S13 filter reflected by Section II-F of the Test Plan, the molds were designed in two phases. In the initial phase the molds were partially completed and parts were molded to precisely determine the mold shrinkages. Then in the final design phase the molds were completed and final grinding operations could reflect the exact shrinkage which would produce the precise plastic dimensions required.

The waveguide cavity mold is shown in its initial phase in Figure 3-29. Initial shrinkage allowances, taken from the General Electric "Valox" Injection Molding Guide, were maximized on all cores and minimized on all cavities to allow grinding to the dimensions required. Figures 3-30, 31, and 32 illustrate these problems to be considered in injection molding this filter. The mold shrinkage allowances are depicted in Table 3-5. The precise shrinkage allowances used in the final phase of the mold are discussed

in Section 3-6-3 of this report.

The mold gating as previously discussed was accomplished through two edge gates. These gates were 0.060" deep with a 0.020" wide gate land to minimize premature plastic freezing. These gates were fed by two 0.375" diameter runners each terminated with a cold well. The gate design drawing is shown in Appendix N in Figure N-1. The waveguide cap mold is shown in its initial phase in Figure 3-33. Here the shrinkages were maximized and minimized as done in the waveguide cavity with the exception of the tuning posts. Shrinkage values for post separations were the mean listed value, 0.006 in./in., and post diameters were 0.020" undersized to allow movement of the posts as well as grinding of the final diameters. The shrinkage values used in the mold are delineated in Table 3-5.

The waveguide cap mold, like the waveguide cavity mold, was designed with an edge gate. This configuration was chosen to produce filters which reflected a dimensional compatibility with the waveguide mold. The single edge gate was 0.100" deep, had a 0.020" wide gate land, and was fed by a 0.375" wide trapezoidal runner. The gate design is depicted in the drawing in Appendix N Figure N-2.

The input-output connector inserts around the connector holes were omitted in the initial mold configuration to determine the degree of movement which would have to be adjusted for in the final configuration.

The mold design was sent to several mold vendors for bidding, and Amerace/Caco-Pacific was chosen to produce the molds.

3.6.3 S13 Mold Design - Final Phase

Upon delivery of the S13 production molds from the vendor to Advanced Manufacturing Technology the injection molding parameters were optimized for the lowest warpage and best surface finish. These molding parameters are depicted in Table 3-6.

A sample lot of 12 filter caps and 12 waveguide cavities was injection molded from each mold. The physical measurements obtained from these parts, along with the mold measurements, were used to establish the molding tolerances and the precise mold shrinkages.

The three standard deviation molding tolerances were well within the Test Plan tolerances called out in Section II-F, thereby demonstrating the repeatability of the process. Mold shrinkages were computed using the existing mold dimensions, the mean part dimensions, and the equation,

$$S^2 + S = \frac{D\ mold}{D\ part} - 1$$

and

$$S = \sqrt{\frac{D\ mold}{D\ part} - 0.75} - 0.5$$

where, S = Shrinkage

D = Mean Dimension

After computing the shrinkages for each critical part dimension the final mold dimensions were derived with,

$$D\ mold_{(final)} = (S^2 + S + 1)\ D\ part_{(final)}$$

With the completion of the final waveguide cavity and cap mold dimensions several other changes were made. Because of extremely close mold mating tolerances tapered venting was added to all mold extremities to reduce air entrapment and burning. The connector inserts, previously omitted to allow connector hole movement, were now added. The molded in waveguide end caps were removed from the mold to optimize plating solution flow in the molded waveguide cavity and to allow the use of a thermal stabilization fixture. Lastly three tapered alignment pins and sleeves were added to both molds to maintain cap-waveguide alignment during assembly. The completed molds are depicted in Figures 3-34 and 3-35.

A waveguide end cap mold shown in Figure 3-36 and in Appendix N Figure N-3 was designed and built to provide end caps, which are attached to the filter assembly with four screws. Upon their completion the waveguide cavity and cap molds were inspected by the Quality Assurance Group, Dept. 27, and were within the tolerances delineated on the drawings in Figures N-1 and N-2 in Appendix N. This certificate of compliance is included in Appendix E and satisfies the requirements of section II-F of the Test Plan.

3.6.4 Post Molding Processes

To overcome the elevated temperature plastic creep which was discussed in Section 3.6.1 of this report, all molded filter parts were subjected to a 20 hour 160^{o}F thermal stabilization. During this stabilization, a fixture, depicted in Figure N-4, Appendix N, was inserted into the waveguide cavity to reduce the stresses which bend the cavity walls inward.

All threaded holes and countersinks ideally could be molded into the filter assembly. However, because of design restrictions and plastic susceptibility to warpage, post molding operations were necessary. The thirteen threaded tuning screw holes could not be molded because of the fine 64 threads per inch. Good design practice limits 'Valox' molded threads to 28 threads per inch. To decrease the labor involved and to increase dimensional accuracy a drill fixture was built. The fixture, depicted in Figure N-5, fits into the waveguide cavity and aligns itself with the three sleeves in the cavity wall. This allows the tuning screw positions to be within 0.002" after drilling and tapping.

The 0.086-56 end cap holes were not molded because of their fineness, nor were inserts molded in as they would interfere with the mold gating. As a result the eight holes were drilled with a template and then tapped. The input and output posts, which are molded into the waveguide, are tapped in the center to allow insertion of the connector pins. To accomplish this, a drill fixture was designed to slip into the cavity and over the post, the drill would then be guided by the upper portion of the fixture now centered over the post. This fixture is illustrated in Figure N-6. After drilling, the holes are tapped with a 1.2-102 metric thread.

With the completion of all molding development portions of this program twenty S13 filters were molded and used in testing to satisfy the requirements of the Test Plan Sections II-F,G,H, and I.

3.7 Copper and Gold Plating of Injection Molded Filters

3.7.1 Copper Thickness and Uniformity

Five waveguide cavities and caps were electroless copper plated for microsectioning and analysis by the Quality Assurance Group, Dept. 27. The uniformity of plating was verified by measuring the thickness of copper at various positions on the waveguide cavities and caps. The five filters met the requirements of Test Plan Section II-G-1 which state that the copper thickness including gold flash

shall be 0.0008" $\pm$ 0.0002" and shall not vary above or below the dimension and tolerance at any given point on the test coupon. The results are tabulated in Quality Assurance Report R394859 and contained in Appendix C.

3.7.2 Surface Finish of Plated Filters

Five copper/gold plated filters were inspected for surface finish on a Taylor Hobson Talysurf 10 Profilometer. Surface finish on the plated injection molded filter varied above and below the 63 finish requirement due to the difficulty in controlling the vapor honing process because of complex part geometry. All filters tested for surface finish were below 100√, and it was observed during electrical test between vapor honed filters and filters which had not been roughened that no deleterious effects to VSWR and insertion loss had occurred. The test results are contained in Appendix G and Table 3-9.

3.7.3 Thermal Shock-Plated Injection Molded Filters

Two thermal shock tests were run on three waveguide filters. The first thermal shock test was water immersion. This harsh test consisted of ten cycles. One complete cycle consisted of immersing a filter into boiling water for ten seconds then removing the filter and immersing it into room temperature running water for ten seconds, and repeating these operations continuously for ten cycles. Figure 3-37 shows a filter immersed in boiling water and Figure 3-38 a filter immersed in room temperature water. The actual test was run in the Department 24-6 laboratory utilizing a flowing water rinse tank instead of the beaker shown in Figure 4-40 which was used for photographic purposes. The three filters met the requirements of Test Plan Section II-H-1 which states that there shall be no longitudinal cracking, blistering, or delamination of the copper plating.

The second thermal shock test run was cycling between the temperature extremes of -40^{o}F and + 160^{o}F for ten cycles. The procedure and apparatus used on the three filters was identical to that of the plated test coupons. A complete description is contained in this report, Section 3.5.7. The three plated injection molded filters met the requirements of Test Plan Section II-H-2 which states that there shall be no delamination or blistering of the gold/copper plating from the polyester substrate. The test results are documented in Quality Assurance Report R 394606 and contained in Appendix H of this report.

3.8 Functional Testing of the Plated Injection Molded Filter

This portion of the program as outlined in Section II-I of the Test Plan was conducted by the Engineering Section, Antennas and Microwave, Group 223 with the results of the testing contained in Appendix I.

3.8.1 Electrical Testing of Injection Molded Filters - Operating Temperature Range

Three filters were tested electrically on an Automatic Network Analyzer HP 8542 and met the requirements as delineated in the Test Plan where an operating temperature range from 40^{O}F to 150^{O}F had to be passed successfully over the pass band and the stop band requirements had to be met over this temperature range.

Average insertion loss over the pass band which had been reduced from $F_c \pm$ 125 MHz to $F_c \pm$ 100 MHz due to the inability of metal production filters to meet this requirement over the operating temperature range at 40^{O}F, 70^{O}F, and 150^{O}F was 1.0 db, 0.99 db and 1.32 db respectively. Average VSWR readings over the temperature range noted was 1:35:1; 1:31:1; and 1:39:1 respectively. Stop band attenuation was read at 60:29; 58:24; and 57:39 respectively.

These results were well above the requirements specified in the Test Plan, Section II-I-1 where insertion loss within the pass band is given as 2 db maximum; VSWR 1·8:1 maximum; and the stop band attenuation at $F_c \pm$ 220 MHz is to be no less than 45 db minimum.

Table 3-10 depicts these results for one filter, GF11.

3.8.2 Non Operating Temperature Cycling of Injection Molded Filters

Ten cycles from -40^{O}F to 160^{O}F was imposed on three filters as specified in II-H-2 and II-I-2(a) to conform to the Test Plan for the non operating condition of the filters. A complete description is contained in Section 3.5.7 where excellent results were achieved.

Appendix I depicts in detail the remainder of the functional testing by Group 223 on Shock, Vibration (Random and Sinusoidal) and Humidity. All filters completed the tests successfully.

TABLE 3-1

THERMAL AND MECHANICAL PROPERTIES OF VARIOUS PLASTICS

Thermoplastic	ABS EP-3510	Lexan 3412	Valox 420-SEO
Deflection Temp. °F 66 psi	206	300	420
Delection Temp. °F 264 psi	189	295	400
Mold Shrinkage In/In	7×10^{-3}	3×10^{-3}	4×10^{-3}
Coefficient of Linear Thermal Expansion Per °F	6.1×10^{-5}	1.5×10^{-5}	3.1×10^{-5}
Thermal Conductivity BTU/hr./ft^2/°/F/in	1.9	1.47	1.3
Water Absorption %	NA	0.16	0.07
Tensile Strength at Yield 1000 psi	6.1	16.0	17.0
Elastic Modulus In Tension 10^5 psi	3.3	8.6	NA
Flexural Strength At Yield 1000 psi	10.5	19.0	27.0
Elastic Modulus In Flexure 10^5 psi	3.4	8.0	11.0

TABLE 3-2

INJECTION MOLDED COUPONS

Tensile Strength

Sample	W (in.)	D (in.)	A (in.^{2})	Force (lbs)	Stress (psi)
0	0.129	0.121	0.0156	275	1.76×10^4
1	0.129	0.121	0.0156	270	1.71×10^4
2	0.130	0.122	0.0158	290	1.82×10^4
3	0.130	0.120	0.0156	270	1.74×10^4
4	0.129	0.120	0.0155	-	No Test
5	0.131	0.121	0.0159	-	No Test
6	0.131	0.121	0.0159	290	1.82×10^4
Test Acceptance Level					1.6×10^4

TABLE 3-3

COMPRESSIVE STRENGTH

Sample	W(in.)	D (in.)	A (in.^{2})	Force (lbs)	Stress (psi)
1	0.491	0.123	6.04×10^{-2}	1235	2.05×10^4
2	0.489	0.123	6.01×10^{-2}	1265	2.11×10^4
3	0.489	0.122	5.97×10^{-2}	1295	2.17×10^4
4	0.490	0.121	5.93×10^{-2}	1340	2.26×10^4
5	0.490	0.122	5.98×10^{-2}	1385	2.32×10^4
6	0.490	0.121	5.97×10^{-2}	1290	2.16×10^4
Test acceptance level			-	-	1.80×10^4

TABLE 3-4

FLEXURAL MODULUS

Sample	b(in)	d(in)	L(in)	P/S(lb/in)	E(psi)
1	0.489	0.122	2.00	500	1.13×10^6
2	0.490	0.123	2.00	542	1.19×10^6
3	0.488	0.122	2.00	505	1.14×10^6
4	0.490	0.123	2.00	552	1.21×10^6
5	0.490	0.121	2.00	508	1.17×10^6
Test plan acceptance level				-	1.00×10^6

TABLE 3-5

METALLIZATION SEQUENCE FOR VALOX 420 SEO

Step No.	Operation	Time
1	Vapor hone thoroughly	-
2	Ultrasonic cleaning (D. I. water)	5 Min
3	MacDermid 9076 conditioner @150^{o}F	10 Min
4	Rinse (D.I. Preferred)	2 Min
5	50% HNO_3 @R/T	5 Min
6	Rinse (D.I. Preferred)	2 Min
7	10% HF @R/T	7.5 Min
8	Rinse (D.I. Preferred)	2 Min
9	20% NaOH @R/T (Neutralizes)	2 Min
10	Ultrasonic cleaning (D.I. water)	5 Min
11	MacDermid 9076 conditioner @150^{o}F	10 Min
12	Rinse (D.I. only)	2 Min
13	Cataprep 505 @R/T	5 Min
14	Cataposit 44 @110^{o}F	5 Min
15	Rinse (D.I. only)	2 Min
16	Shipley Accelerator 19 @R/T	5 Min
17	Rinse (D.I. only)	1 Min
18	Shipley CP-70 Electroless Copper @110^{o} - 120^{o}F until 0.8 mil thick	-
19	Gold Flash (75 millionths thick)	-

TABLE 3-6

CRITICAL MOLD SHRINKAGE ALLOWANCE

PART	DIRECTION	ALLOWANCE	FLOW DIRECTION
Waveguide Cavity	Length	+.010 in/in	Flow
Waveguide Cavity	Width	+.020 in/in	Cross Flow
Waveguide Cavity	Depth	+.020 in/in	Cross Flow
Cap-beam	Length	+.002 in/in	Flow
Cap-beam	Width	+.002 in/in	Cross flow
Cap-Posts	Center spacing	+.006 in/in	Flow
Cap-Posts	Depth	+.010 in/in	Flow
Cap-Posts	Diameter	-.020 All	Not Appl.

TABLE 3-7

INJECTION MOLDING CONDITIONS FOR S13 PLASTIC FILTER

Waveguide Cavity And Cap	Parameter	Value	Tolerance
"	Mold Temperature	75°F	± 10°F
"	Nozzle Temperature	500°F	± 5°F
"	Barrel-Front Zone	490°F	± 5°F
"	Barrel-Rear Zone	480°F	± 5°F
"	Injection Pressure	1,500 psig	± 20 psig
"	Hold Pressure	1,100 psig	± 20 psig
"	Back Pressure	50 psig	± 10 psig
"	Injection Time	2 sec	± 0.5 sec
"	Hold Time	30 sec	± 0.5 sec
"	Cycle Time	180 sec	± 1 sec
"	Injection Speed	Maximum Possible	-
"	Screw Speed	60 rpm	± 10 rpm
Waveguide Cap	Shot Size	1.25 oz	± 0.1 oz
Waveguide Cavity	"	2.0 oz	± 0.1 oz

TABLE 3-8

SURFACE FINISH OF PLATED TEST COUPONS

Sample	Surface Finish (RMS) Side A	Surface Finish (RMS) Side B
65	60	61
66	45	60
67	62	46
68	60	60
69	47	44
71	58	48

TABLE 3-9

SURFACE FINISH OF PLATED FILTERS

Filter	Surface Finish (RMS) Cap	Surface Finish (RMS) Cavity
1	52	64
2	80	60
3	87	53
4	42	66
5	71	93

TABLE 3-10

ELECTRICAL DATA OVER THE OPERATING TEMPERATURE RANGE
FOR FILTER GF-11

Temperature (^oF)	Pass Band VSWR (Ave.)	Insertion Loss Pass Band dB (Ave.)	Stop Band Attenuation (Ave.)
40^o	1.35:1	1.00	60.29
70^o	1.31:1	0.99	58.24
150^o	1.39:1	1.32	57.39
Specifications	1.8:1 Maximum	2.0 Maximum	45.0 Minimum

TABLE 3-11

COST OF THE FIRST TEN S-13 FILTERS FOR PHALANX

Part #5188423 Metal Filter

1. Outside Purchase Costs

Machining, end plates, cap, and body	$ 138.00
Assemble and Aluminum braze	$ 125.00
Finishing, immersion zinc, copper and gold plate	$ 210.00
Total O.S.P.	$ 473.00

2. Factory Costs

2-1 Assembly Parts

Inserts	22	$ 7.20
Screws	30	$ 2.10
Washers	30	0.60
Connector Assembly (2)		$ 6.32
Tuning Screws		$ 32.50
Total Parts Cost		$ 48.72

2-2 Labor Cost Etc.

Factory	$ 109.10
Inspection	$ 21.89
Overhead	$ 318.65
Raw Material	$ 5.06
	$ 454.70

2-3 Tuning The S-13 Filter

Six hours average time	$ 156.00
Total Cost of S-13 Filter	$ 1,132.42

TABLE 3-11 (Continued)

COST OF THE FIRST TEN S-13 FILTERS FOR PHALANX

Added Cost for First 10 Filters		
1st Filter Cost	$	2,750.00
11 Change orders to relax Tolerance #5188425	$	1,100.00
7 Change orders on metal finishing #5188425	$	700.00
8 Change orders to relax tolerance #5188424	$	800.00
Tooling costs paid by G.D.	$	650.00
Rejection rate on 1st 10 was 50%		
Average cost of first 20 was $1,942.00		
Cost of rejected parts	$	19420.00
Cost	$	25420.00

$\frac{25420.00}{10}$ = $2542.00 Added cost by rejects etc. each

Total cost for filter #10 is			
	Present Cost	$	1,132.42
	Added Cost	$	2,542.00
Average cost of first ten filters		$	3,674.42

TABLE 3-12

INJECTION MOLDED FILTER COSTS

I Fabrication Costs

Materials

Valox 500 lb lots $2.68/lb.

Filter Cap	.09 lbs x $2.68/lb =	$	0.24
Waveguide body	.19 lbs x $2.68/lb =	$	0.51
End Caps (2)	.006 lbs x $2.68/lb =	$	0.01
Inserts (22)	@ 35¢ =	$	7.70
Screws (30)	@ 7¢ =	$	2.10
Washers (30)	@ 2¢ =	$	0.60
Connector Assembly (2)	@ $3.16 =	$	6.32
Tuning Screws (13)	@ $2.50 =	$	32.50
	Total Fabrication Material	$	49.98

Labor

Waveguide Body (Insert Loading and Injection Molding)	10 Min
Filter Cap. (Insert Loading and Injection Molding)	10 Min
End Caps (2) Injection Molding	2 Min
Drill Filter Cap	4 Min
Drill End Caps	2 Min
Countersink Filter Cap	4 Min
Countersink End Caps	2 Min
Gate Removal from Filter Cap	2 Min
Gate Removal from Waveguide Body	4 Min

TABLE 3-12 (Continued)

INJECTION MOLDED FILTER COSTS

I Fabrication Costs

Labor

Tap Both Ends of Filter Cap	1 Min
Deburr and Remove Flash (Filter Cap)	4 Min
Deburr and Remove Flash (Waveguide Body)	6 Min
Drill Tuning Screw Holes (13) in Waveguide Body	3 Min
Countersink Tuning Screw Holes (13)	4 Min
Tap Tuning Screw Holes (13)	8 Min
Drill Holes at Ends of Waveguide Body (4)	3 Min
Drill Holes (2) Into Input and Output Waveguide Posts	3 Min
Tap Holes (4) Into Input and Output Waveguide Posts	4 Min
Environmental Stabilization of Filter Cap and Waveguide Body	6 Min

Total Labor-Fabrication = 1 Hr 22 Min

Labor Cost = $25/hr x 1 hr 22 Min = $34.16

TABLE 3-12 (Continued)

INJECTION MOLDED FILTER COSTS

II Plating Costs

Materials

.75 Silica Blend Grit	@ $0.40/lb. 0.5 lb x $0.40/lb =	$0.20
HNO_3	@ $3.77/lb,	
HF	@ $3.80/lb,	= $0.10
NaOH	@ $7.50/lb,	
Cataprep 505	@ $2.00/liter	
Cataposit 44	@ $85.49/liter	
Acceleration 19	@ $3.56/liter	= $2.70
CP70-A	@ $0.93/liter	
CP70-Z	@ $1.60/liter	
CP70-M	@ $3.38/liter	
Metal finishing pad	@ $0.40/Sheet	= $0.40
Gold Plating	@ $800.00/oz	
	Thickness = 75 x 10^{-6} in.	= $0.15
	Total Plating Material	= $3.55

Labor

Vapor hone	10 Min
Etch	15 Min
Electroless Copper Plate	15 Min
Polish	30 Min
Electrolytic Gold Plate	5 Min

Total Labor-Plating = 1 hr, 15 Min

Total Labor Cost = $25.00/hr x 1 hr, 15 min = $31.25

TABLE 3-12 (Continued)

INJECTION MOLDED FILTER COSTS

III Assembly Costs

Labor

1.	Insert connector pins (2) into input and output posts. Solder pins to post (2).	8 Min
2.	Place filter cap over waveguide body and over connector pins engaging alignment pins of the filter cap with the alignment holes in the waveguide body.	2 Min
3.	Fasten cap to waveguide body with 14 screws and washers, torque to 4 in-lbs.	15 Min
4.	Cut teflon dielectric to proper height then engage over connector pins (2).	6 Min
5.	Assemble connectors (2) over teflon dielectric and fasten with (8) screws and washers. Torque to 3 in-lbs.	6 Min
6.	Insert (13) tuning screws. Check for complete travel through waveguide.	15 Min
7.	Place end caps (2) over filter assembly. Fasten with (8) screws. Torque to 2 in-lbs.	10 Min

Total Labor - Assembly = 1 hr 12 Min

Total Labor Costs - Assembly = $30.00

(25$/hr x 1 hr 12 min)

TABLE 3-12 (Continued)

INJECTION MOLDED FILTER COSTS

IV Tuning Costs

1. Tune filter 20 Min

Labor Costs (25$/hr x 0.33 hr.) = $8.33

V Tooling Costs

Injection Molds	$20,175.00
Tuning Screw Drill Fixture	$2,000.00
Temperature Stabilization Fixtures	$200.00
Input-Output Pin Drill Fixture	$200.00
Total Tooling Costs	$22,575.00

TABLE 3-12 (Continued)

INJECTION MOLDED FILTER COSTS

S13 Molded Filter

Total Costs

I	Fabrication	Labor Cost	$ 34.16
		Material Costs	$ 49.98
II	Plating	Labor Costs	$ 31.25
		Material Costs	$ 3.55
III	Assembly	Labor Cost	$ 30.00
IV	Tuning Cost		$ 8.33
	Total Cost of Filter		$ 157.27
V	Total Tooling Costs		$23,375.00

TABLE 3-13

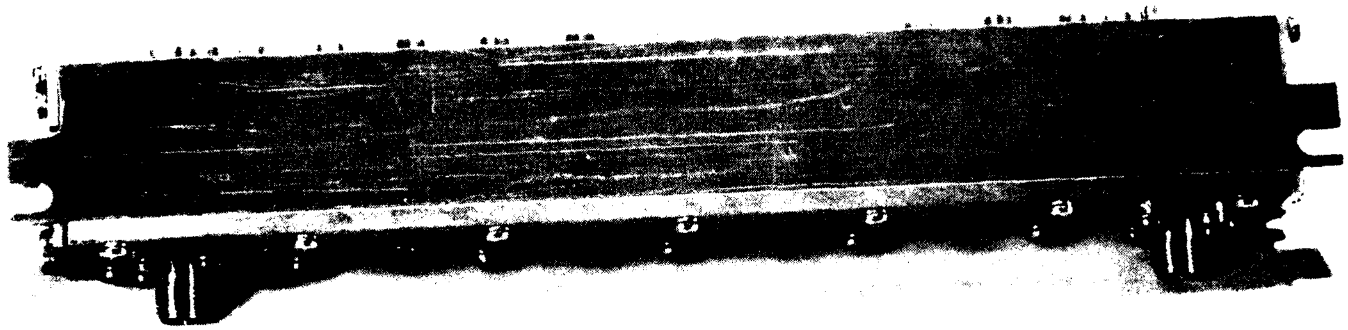
METRIC CONVERSION TABLE

English Units	Metric (SI) Units	Conversion Factor
Given	To Obtain	Multiply by
Length		
Inch (in)	Meter (m)	2.540×10^{-2}
Foot (ft)	Meter (m)	3.048×10^{-1}
Area		
Inch^2 (in^2)	Meter^2 (m^2)	6.452×10^{-4}
Foot^2 (ft^2)	Meter^2 (m^2)	9.290×10^{-2}
Volume		
Inch^3 (in^3)	Meter^3 (m^3)	1.639×10^{-5}
Foot^3 (ft^3)	Meter^3 (m^3)	2.832×10^{-2}
Gallon (gal)	Liter (l)	3.785
Force		
Pound (lb)	Newton (N)	4.448
Mass		
Slug	Kilogram (Kg)	1.459×10^{1}
Pound (lb)	Kilogram (Kg)	4.536×10^{-1}
Pressure		
lb/in^2 (psi)	Pascal (Pa)	6.895×10^{3}
in. of Hg (60^{o}F)	Pascal (Pa)	3.377×10^{3}
Torque		
in.-lb	Joule (J)	1.130×10^{-1}
Temperature		
^{o}F	^{o}C	$(T_{oF} - 32)/1.8$

TABLE 3-13 (Continued)

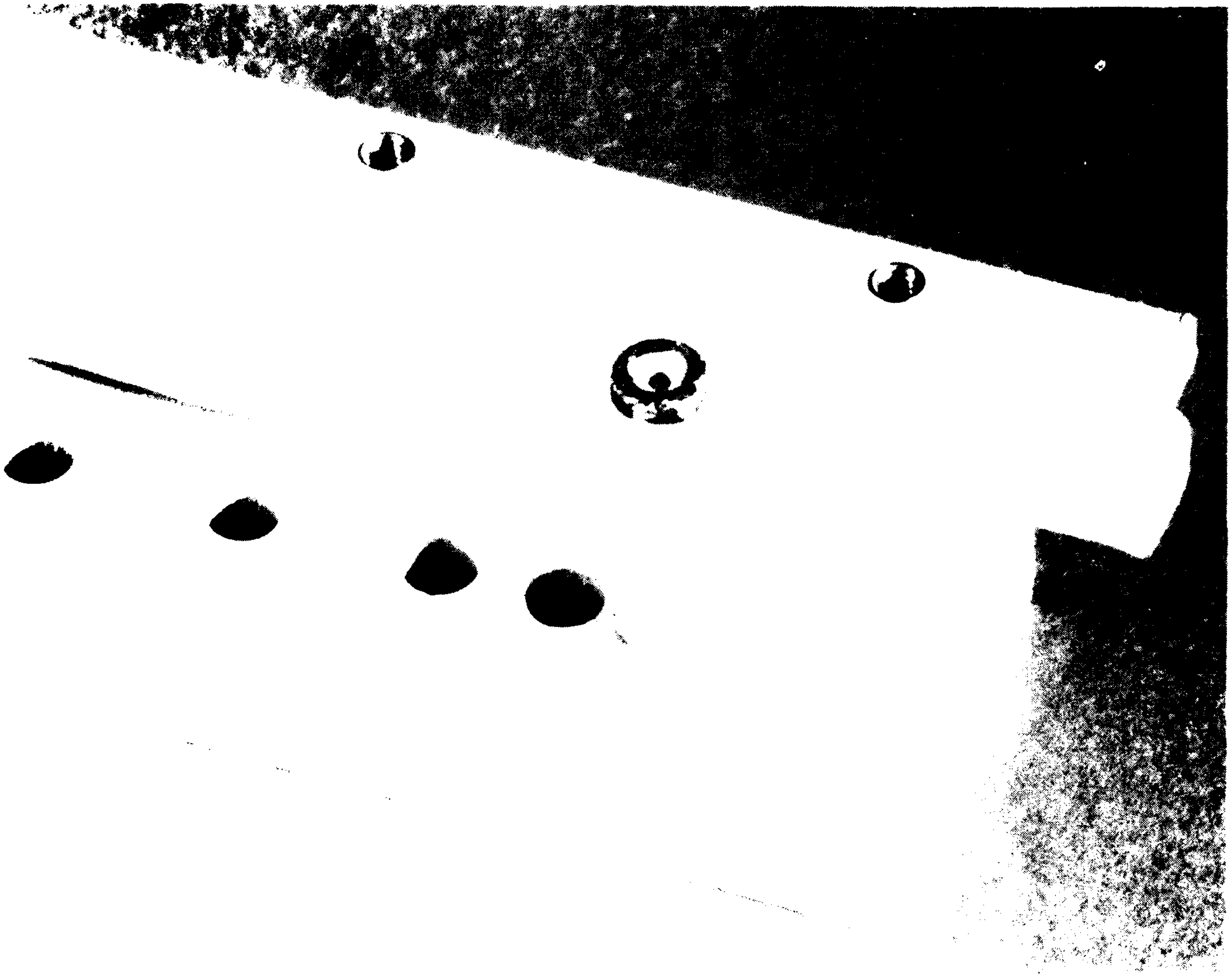
METRIC CONVERSION TABLE

English Units	Metric (SI) Units	Conversion Factor
Thermal Conductivity		
BTU-in/hr-ft^2-^{o}F	Cal-cm/sec-cm^2-^{o}C	2.923×10^3
Density		
lb/in^3	Kg/m^3	2.768×10^4
lb/ft^3	Kg/m^3	1.602×10^1
Flow Rate		
Gal/min	l/min	3.785



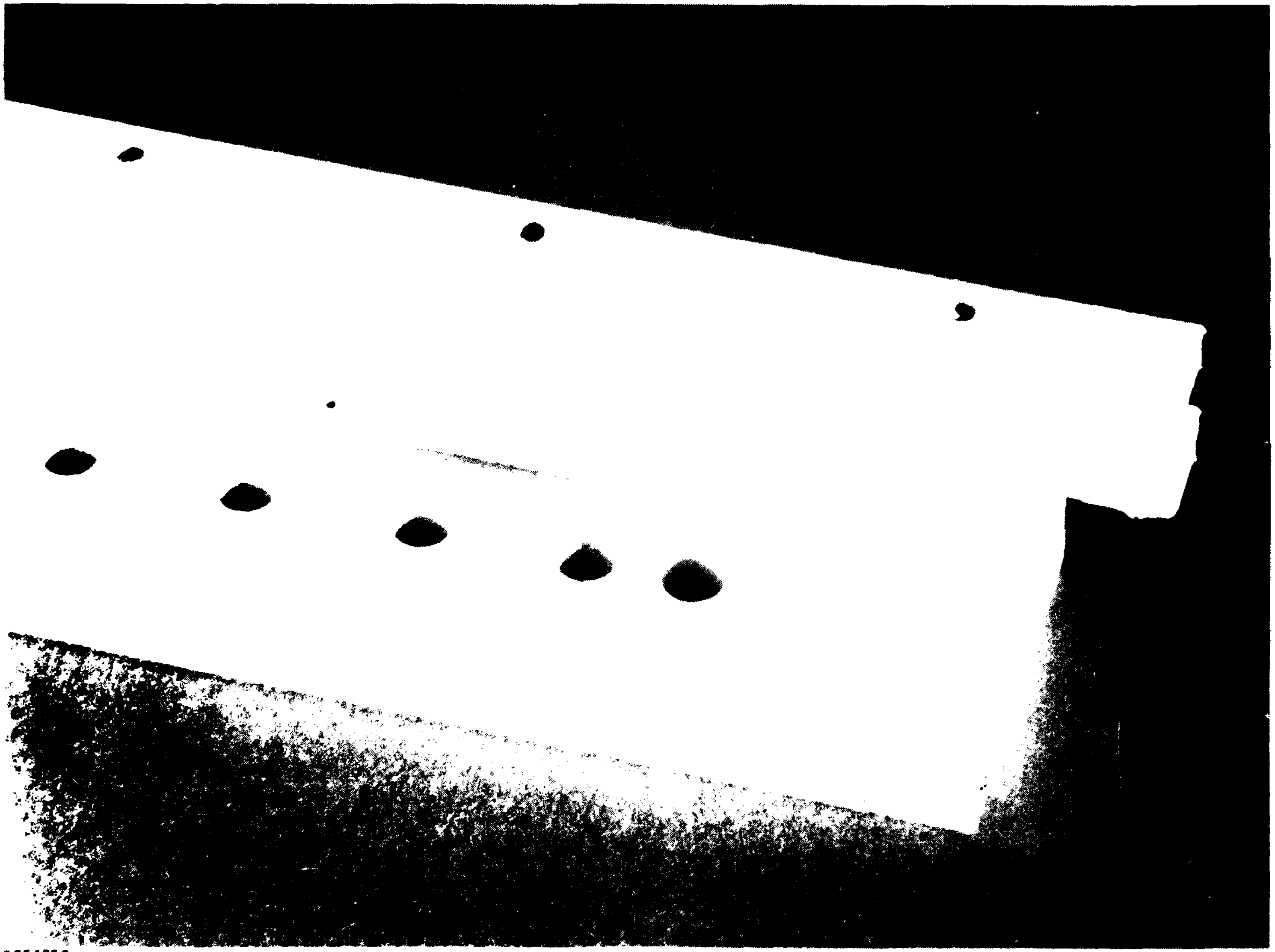
A254350

Figure 3-2. Machined Aluminum Filter



A254351

Figure 3-3. ABS Injection Molded Filter Showing Sink at Output Post



A254352

Figure 3-4. Valox Injection Molded Filter Showing Smooth Molded Surfaces

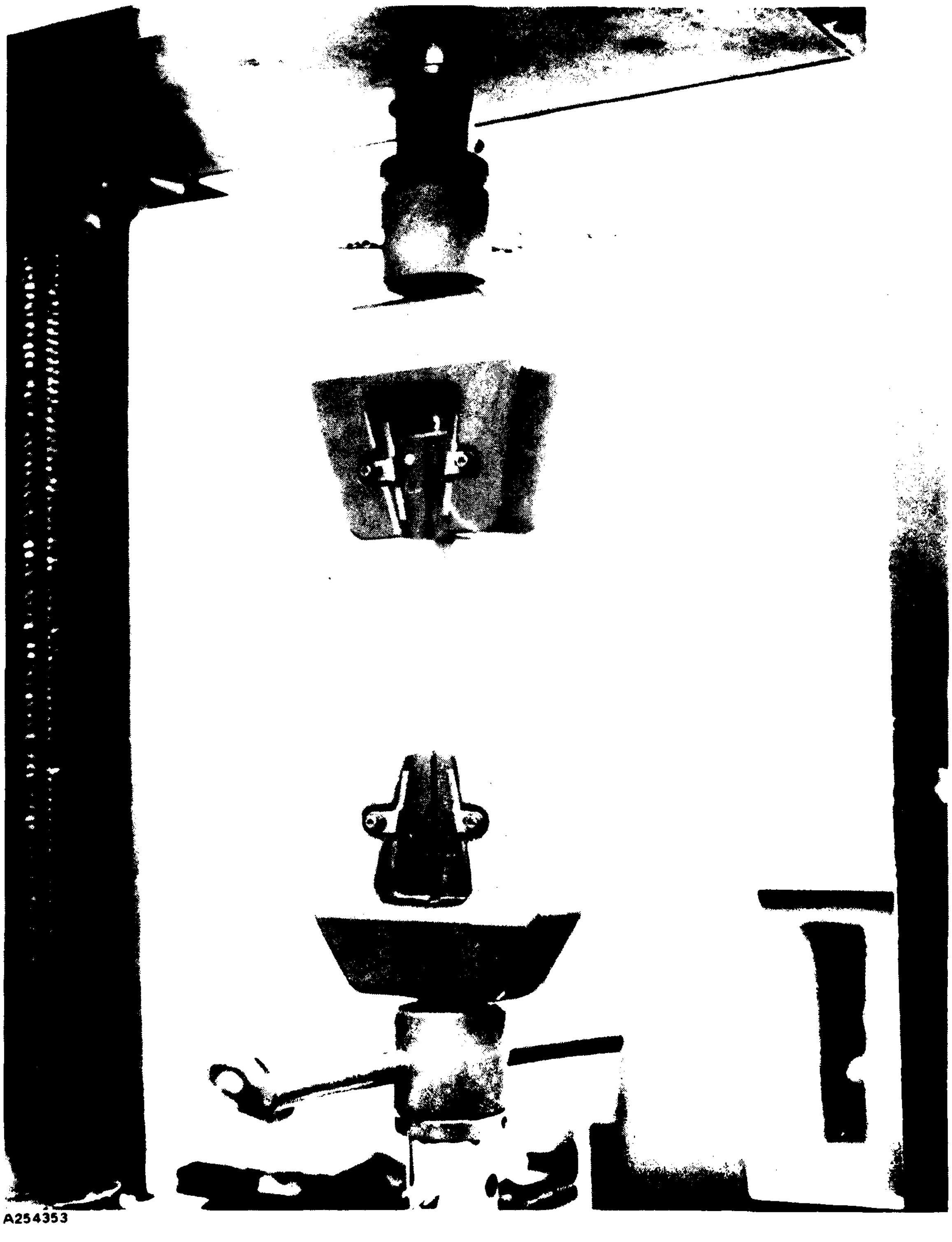
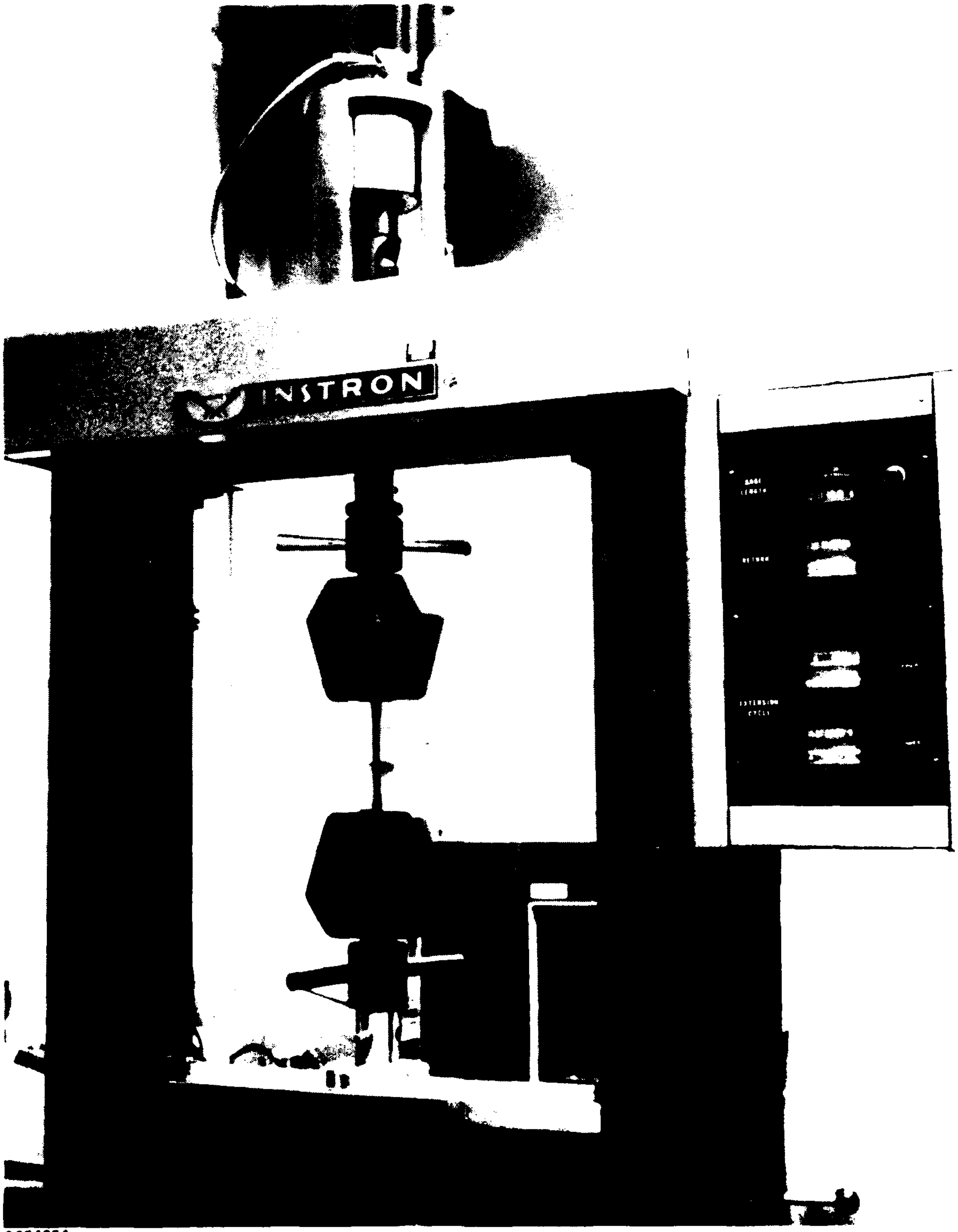
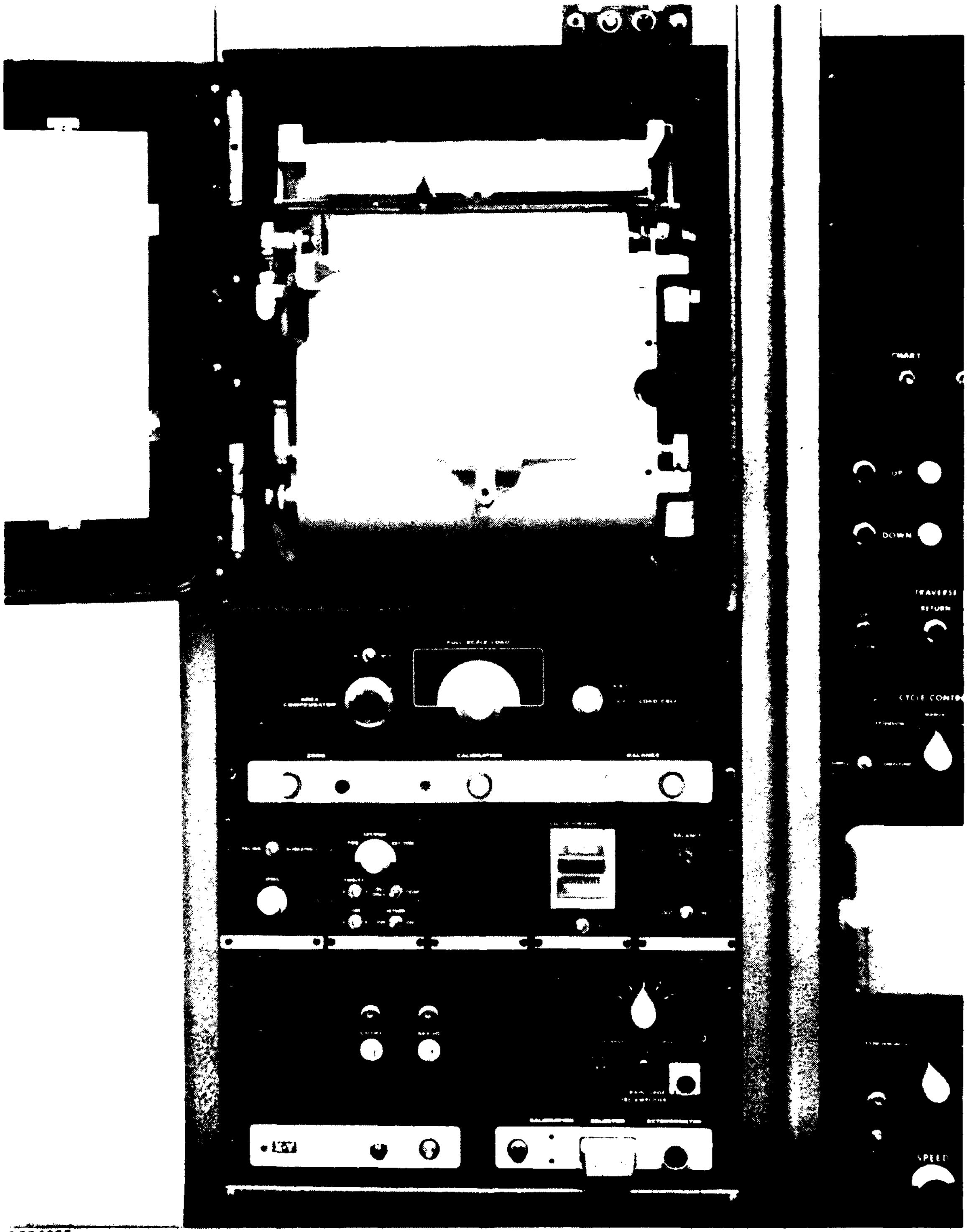


Figure 3-5. Instron Universal Testing Machine - Sample in Load Jaws



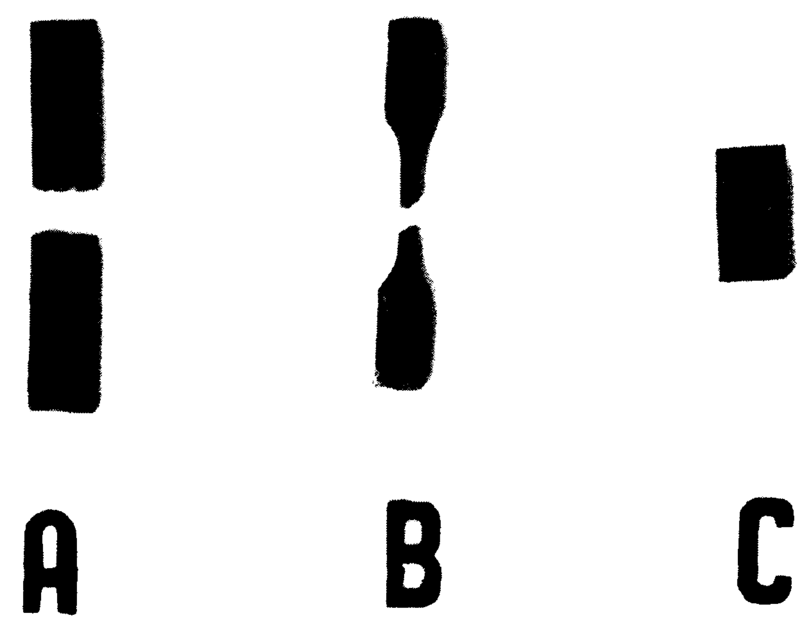
A254354

Figure 3-6. Instron Universal Testing Machine - Set-Up in Tension Mode



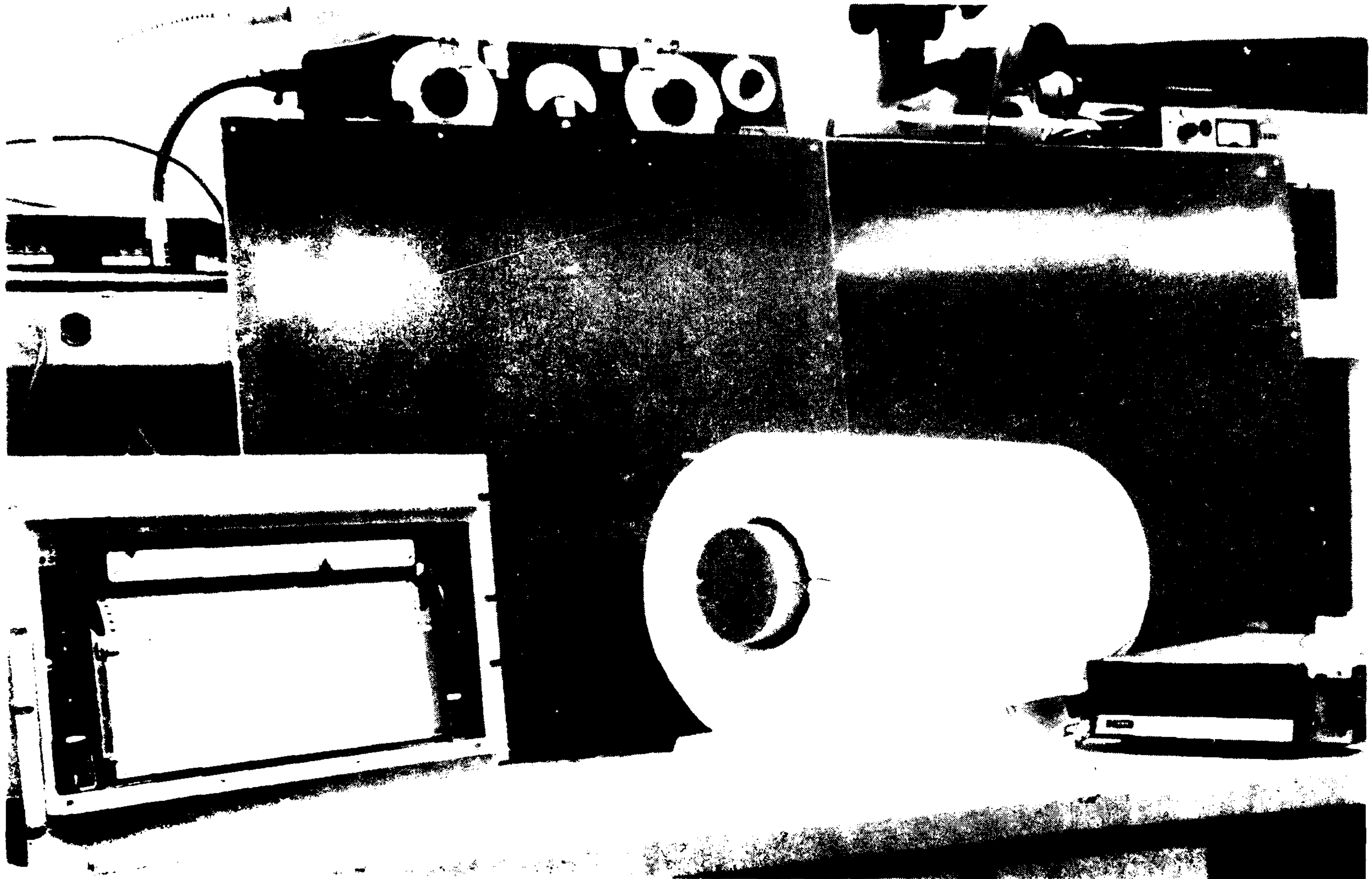
A254355

Figure 3-7. Instron Universal Testing Machine - Chart Drive



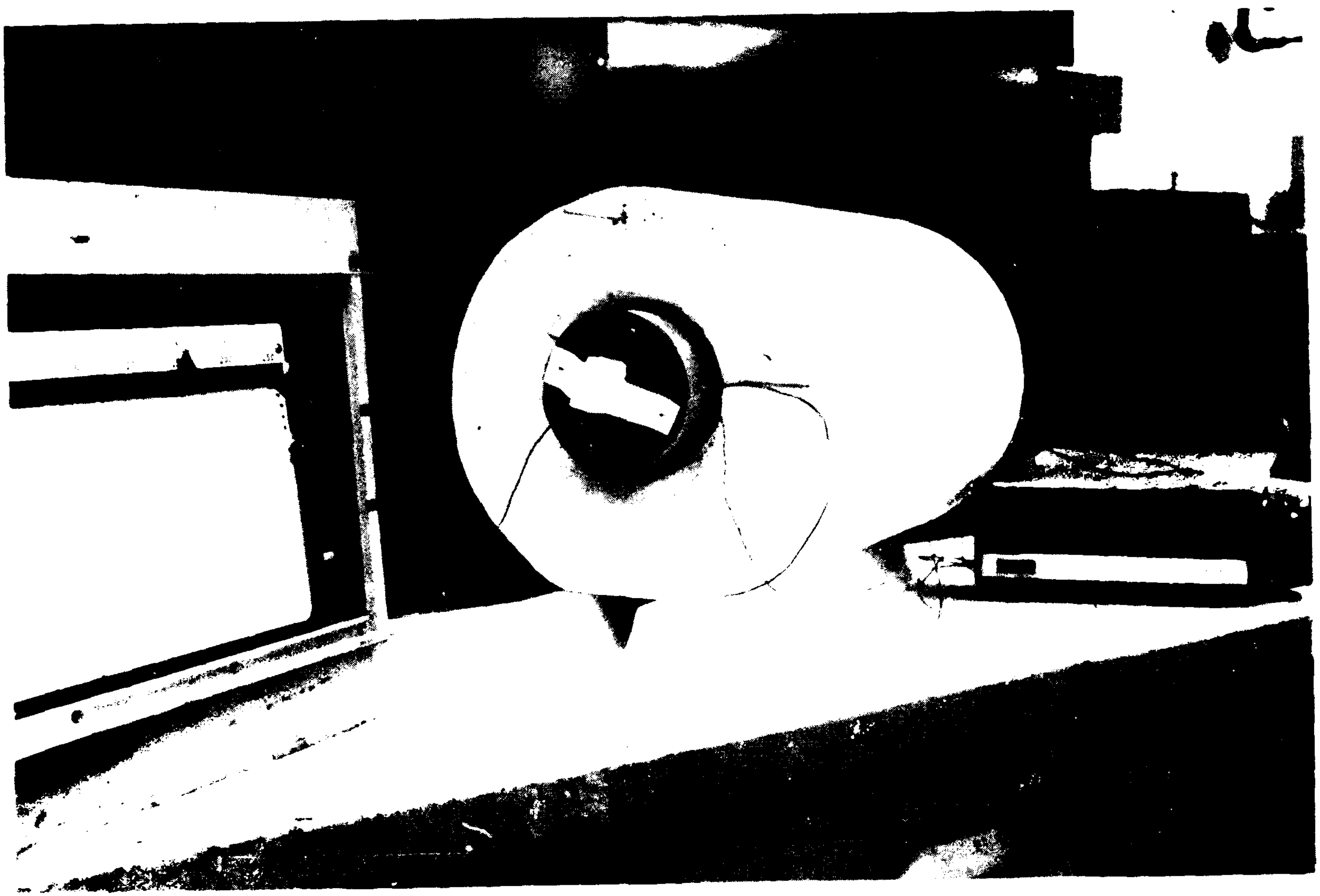
A254356

Figure 3-8. Valox Physical Properties Test Coupons



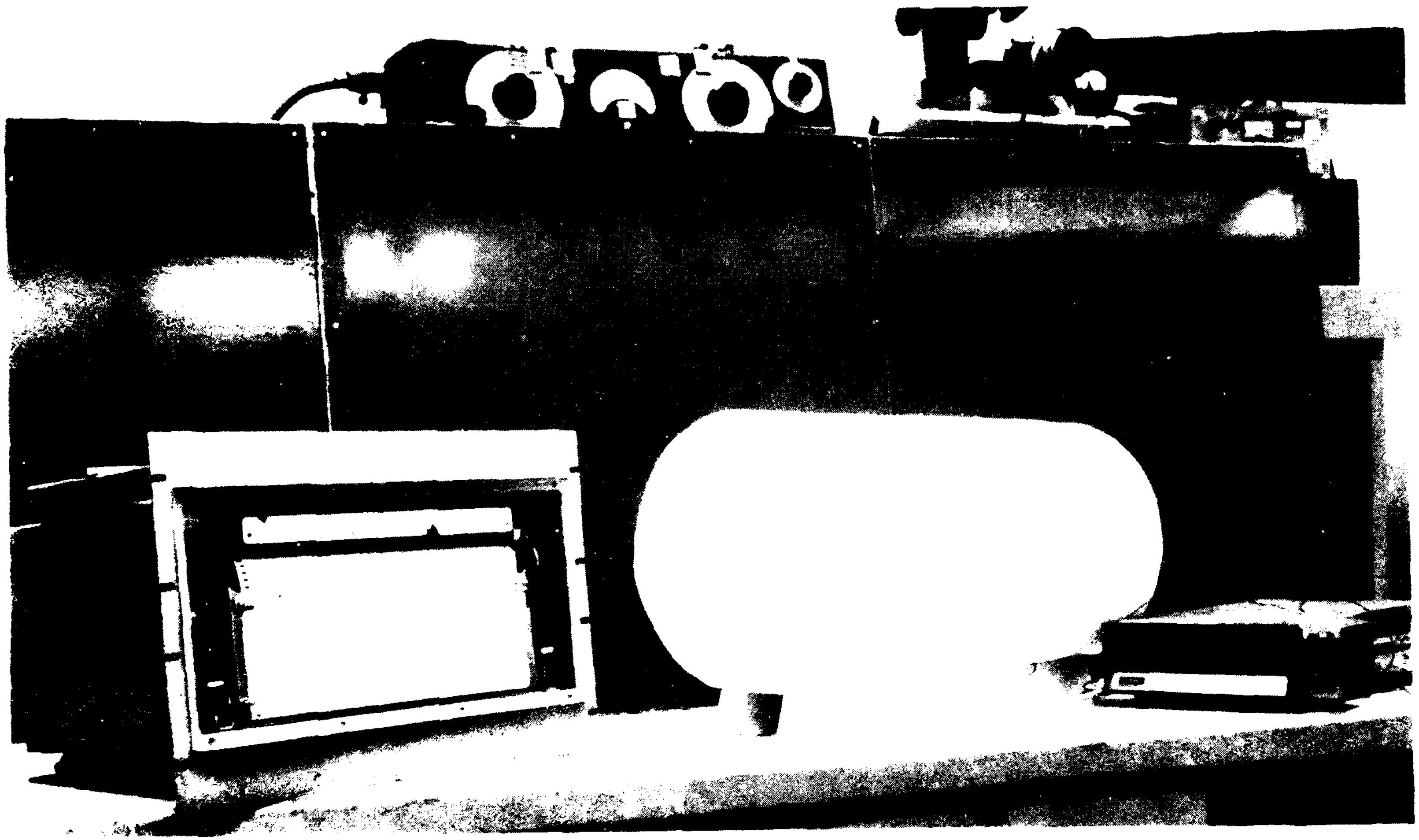
A254357

Figure 3-9. *Thermal Conductivity Test - Constant Heat Source*



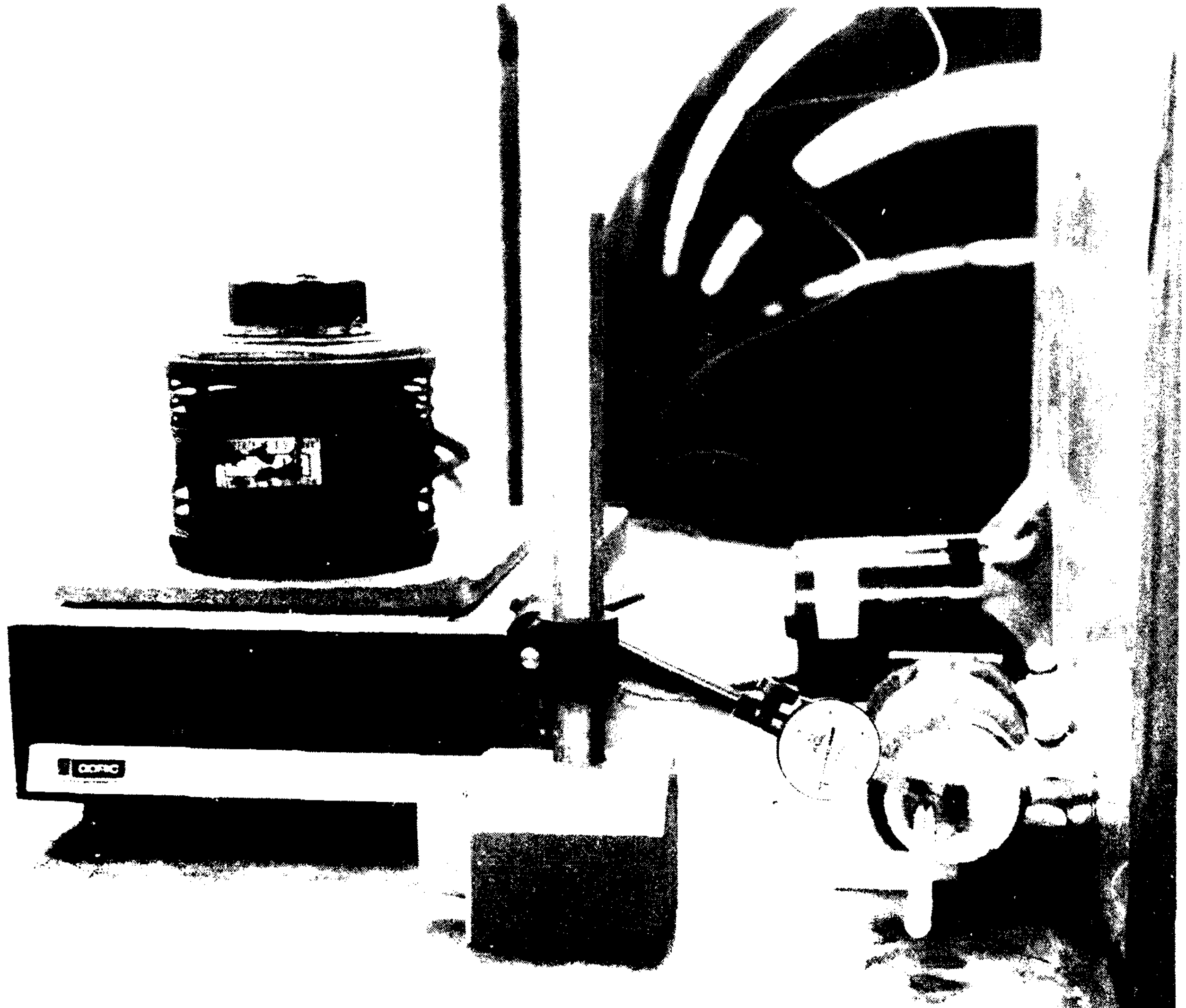
A254358

Figure 3-10. Thermal Conductivity Test - Valox Sample and Thermocouples Mounted



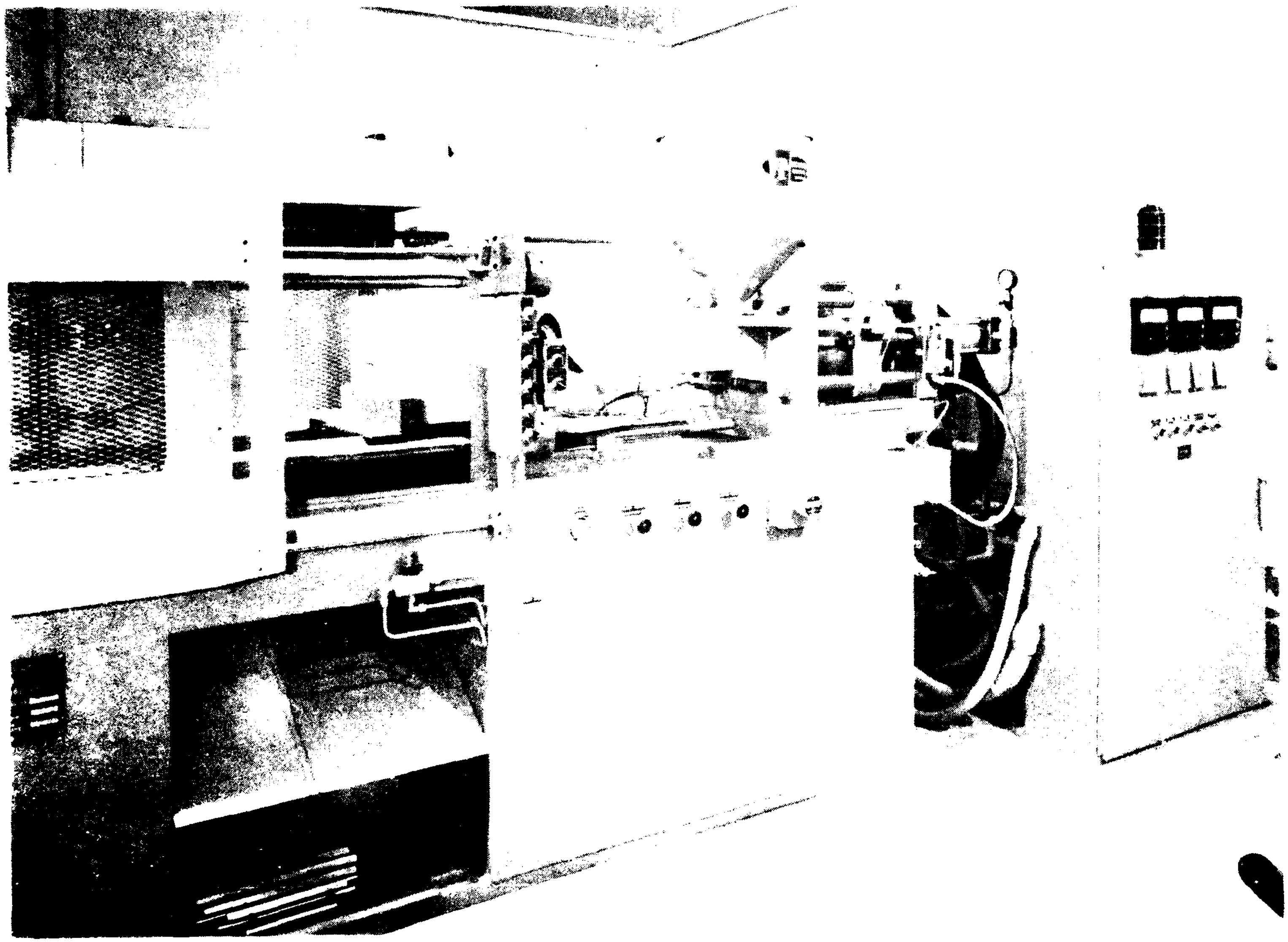
A254359

Figure 3-11. Thermal Conductivity Test - Constant Heat Source and Valox Sample Enclosed



A254360

Figure 3-12. Thermal Expansion Test - Sample Being Cooled by Alcohol Coolant



A254361

Figure 3-13. Newbury 160-Ton Injection Molder

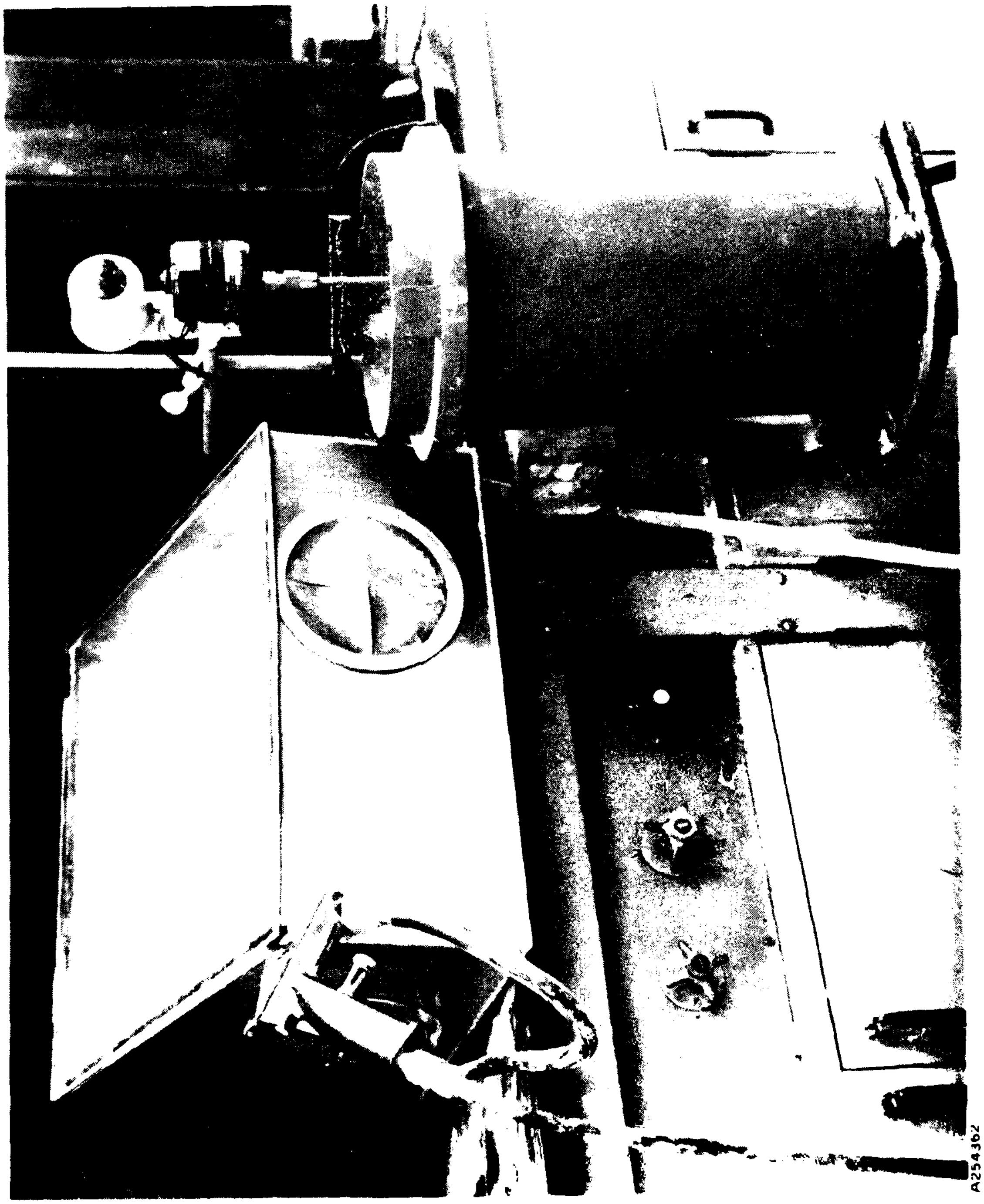
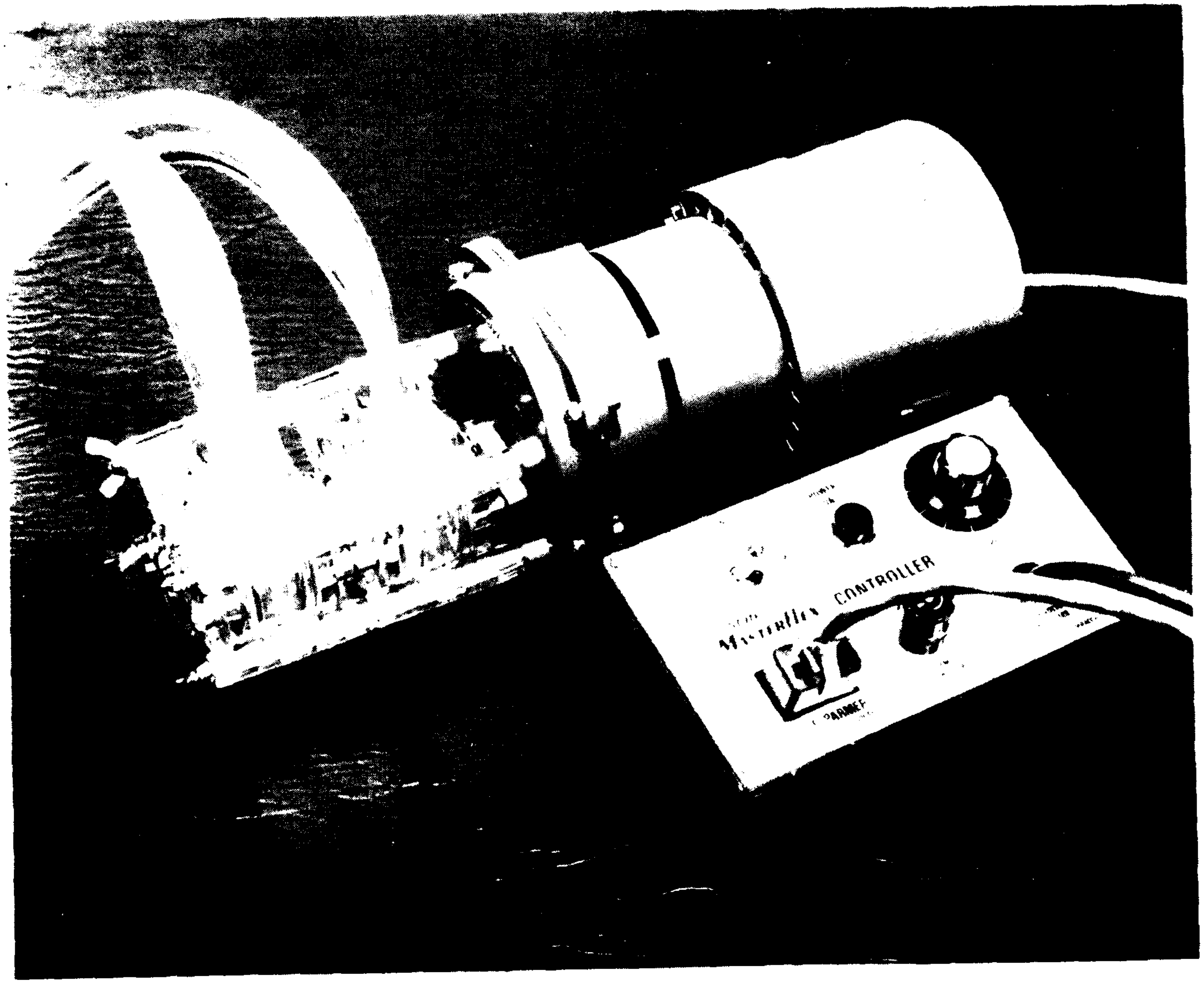
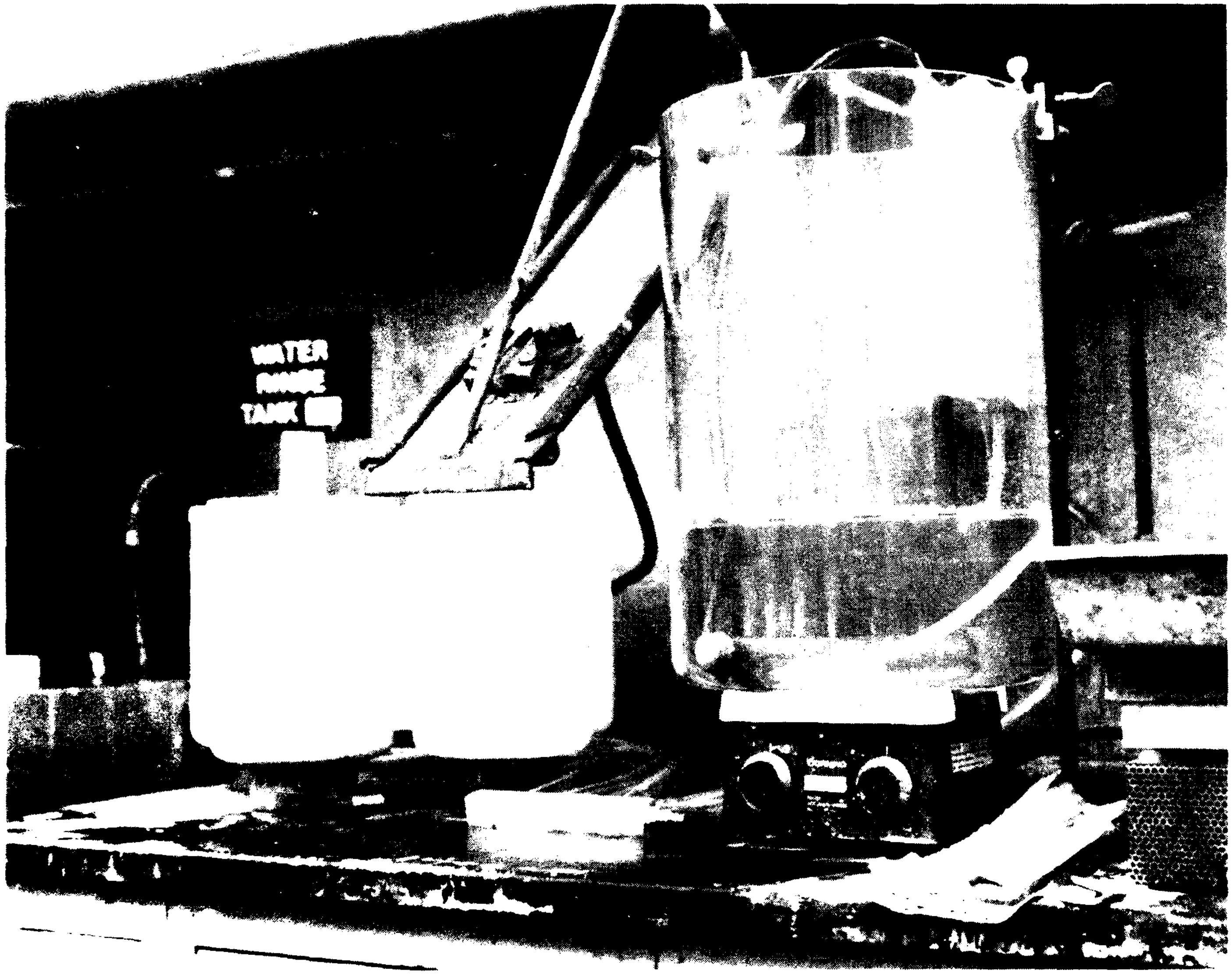


Figure 3-14. Vapor Honing Apparatus



A254363

Figure 3-15. Filtration and Circulation Tube Pump



A254364

Figure 3-16. Electroless Copper Plating Set-Up

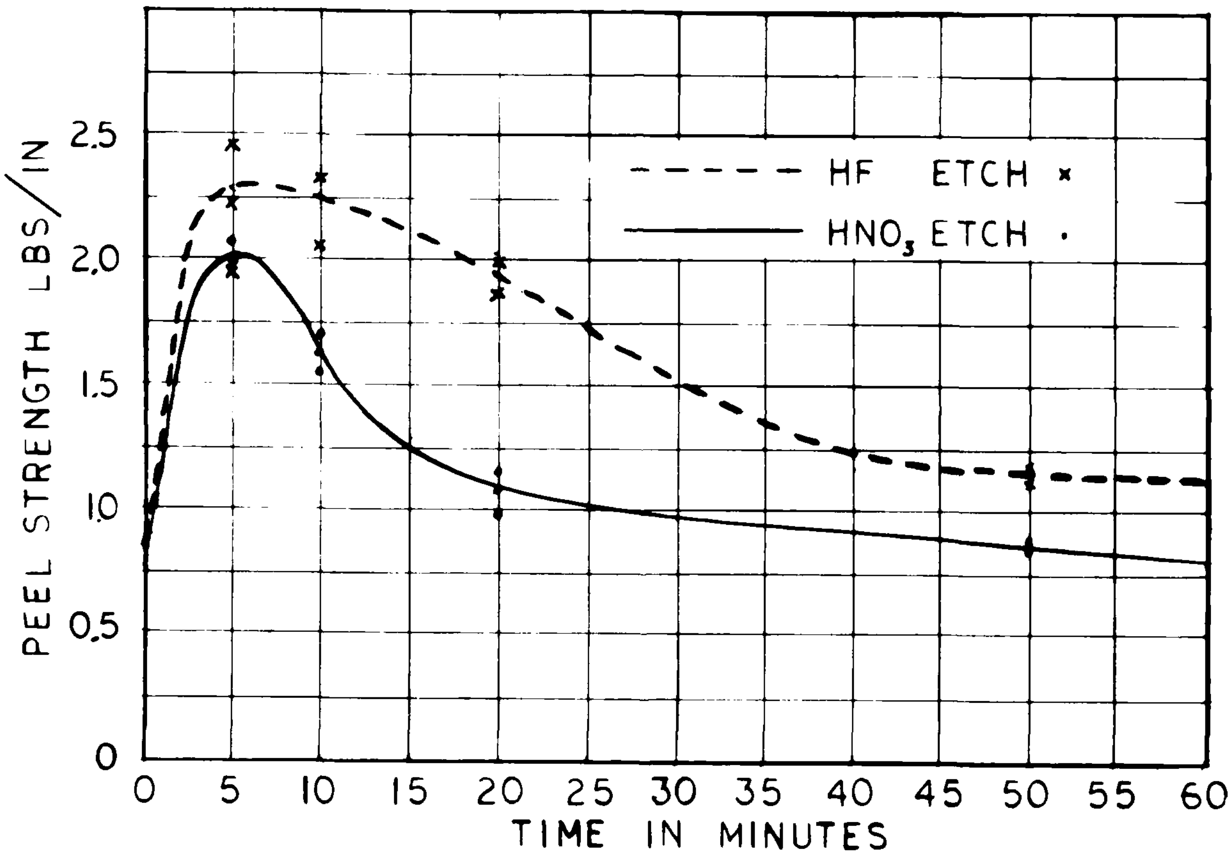


Figure 3-17. Peel Strength Versus Amount Of Etching Time

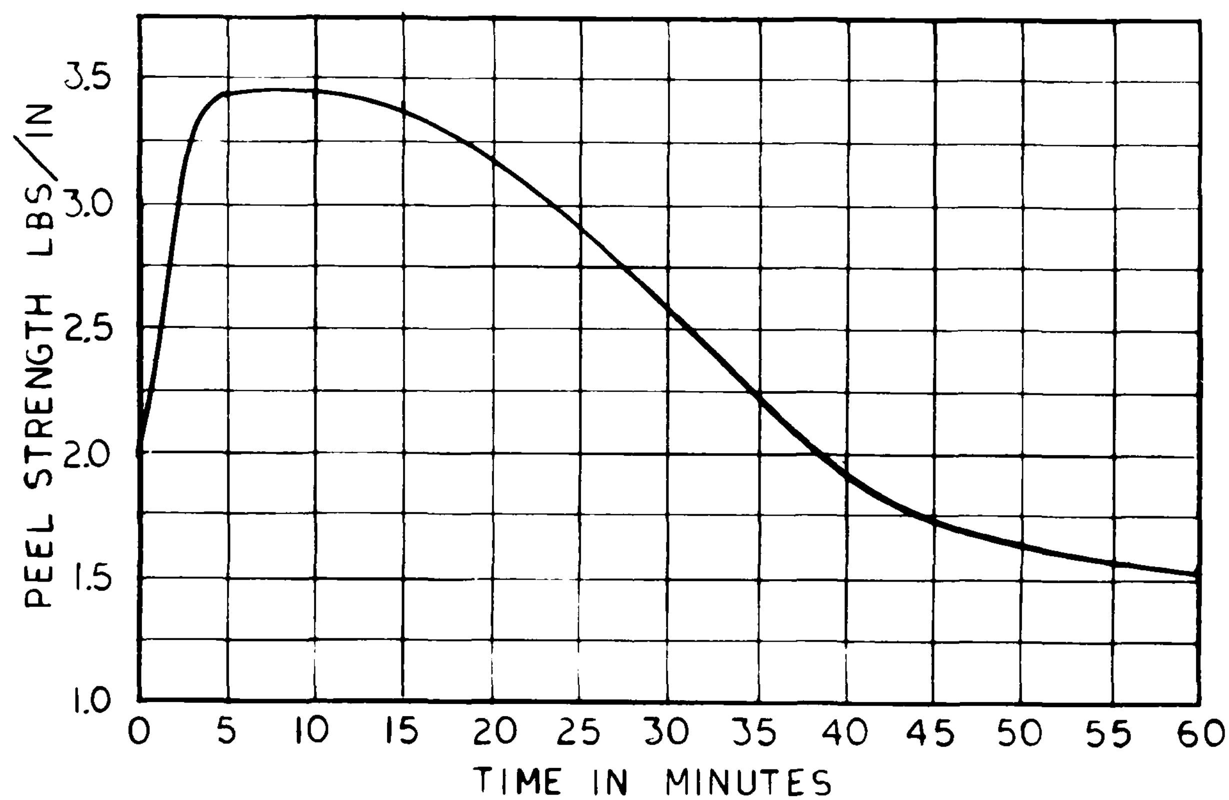


Figure 3-18. Peel Strength Versus Time In HF Etch With 5 Min. HNO_3 Etch

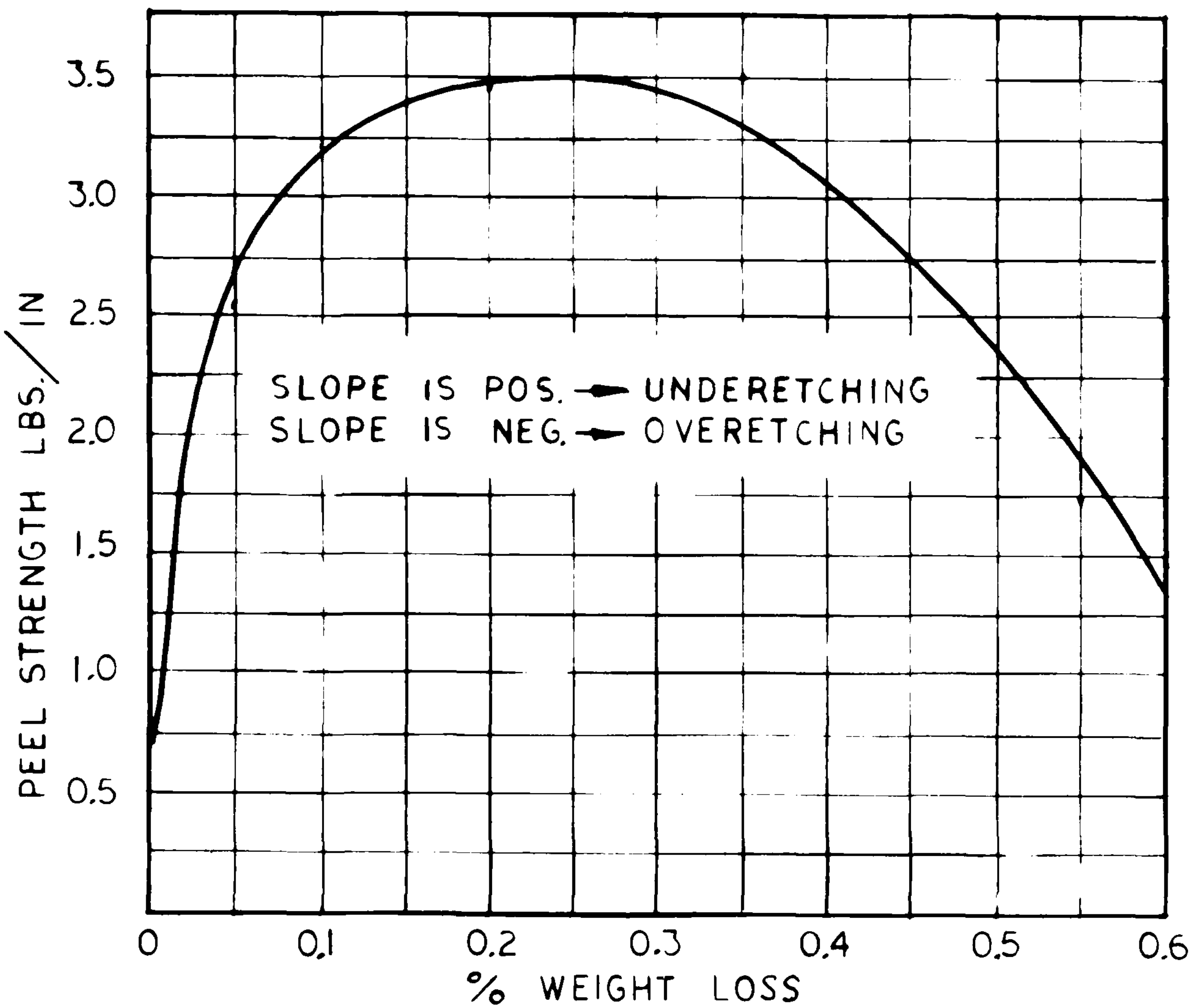


Figure 3-19. Peel Strength Versus % Weight Loss

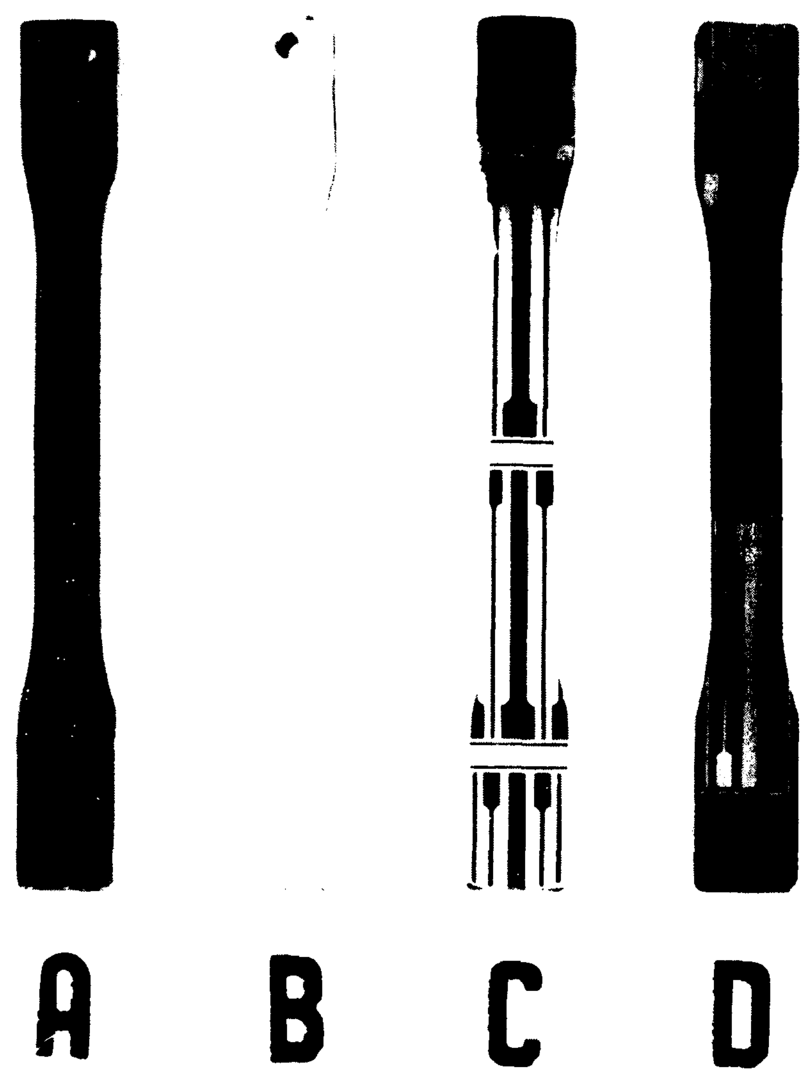
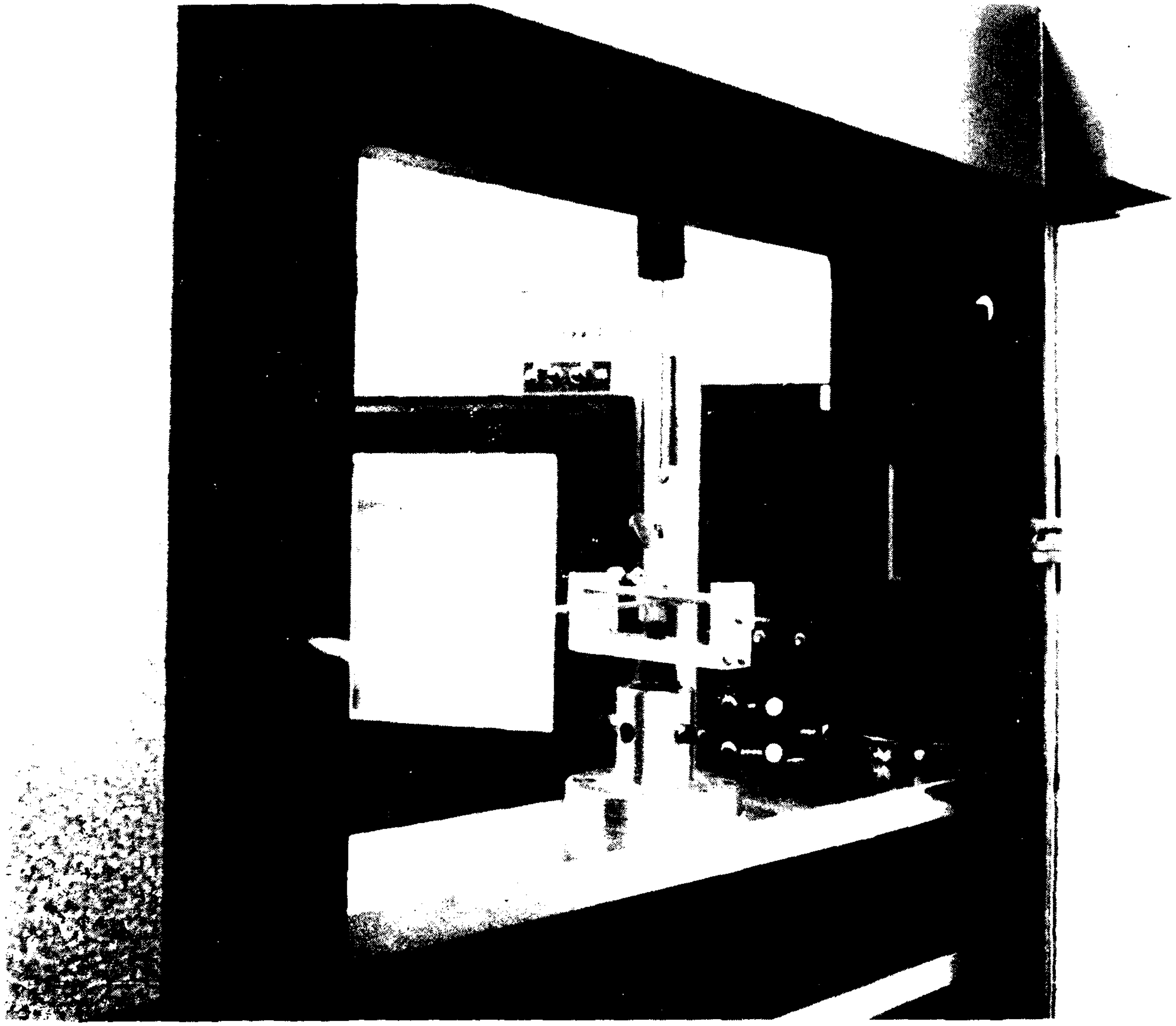


Figure 3-20. Peel Test Sequence - Valox 420-SEO Test Coupons

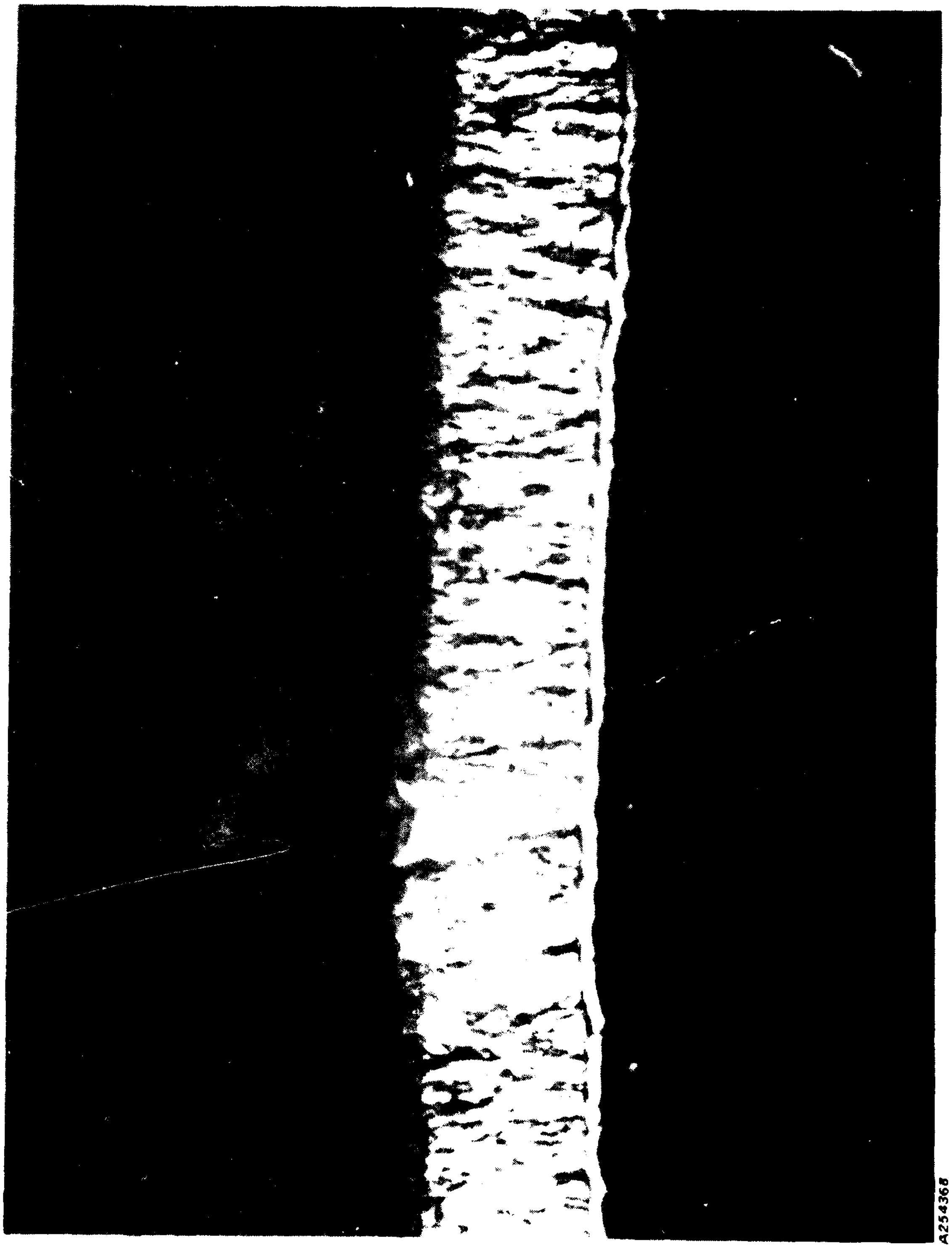


A254366

Figure 3-21. Peel Test Set-Up

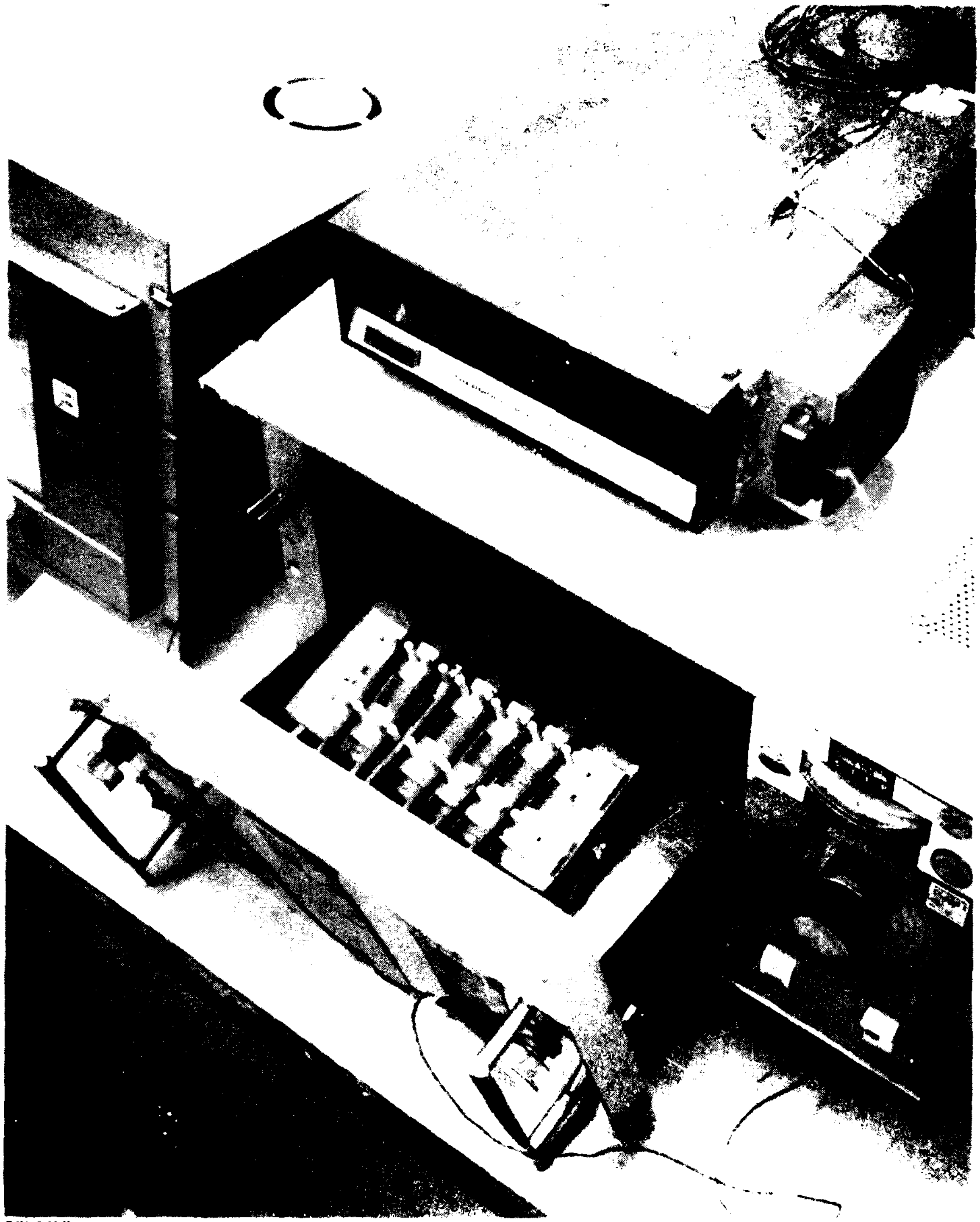
A254367

Figure 3-22. Peel Test Being Performed on Instron Machine



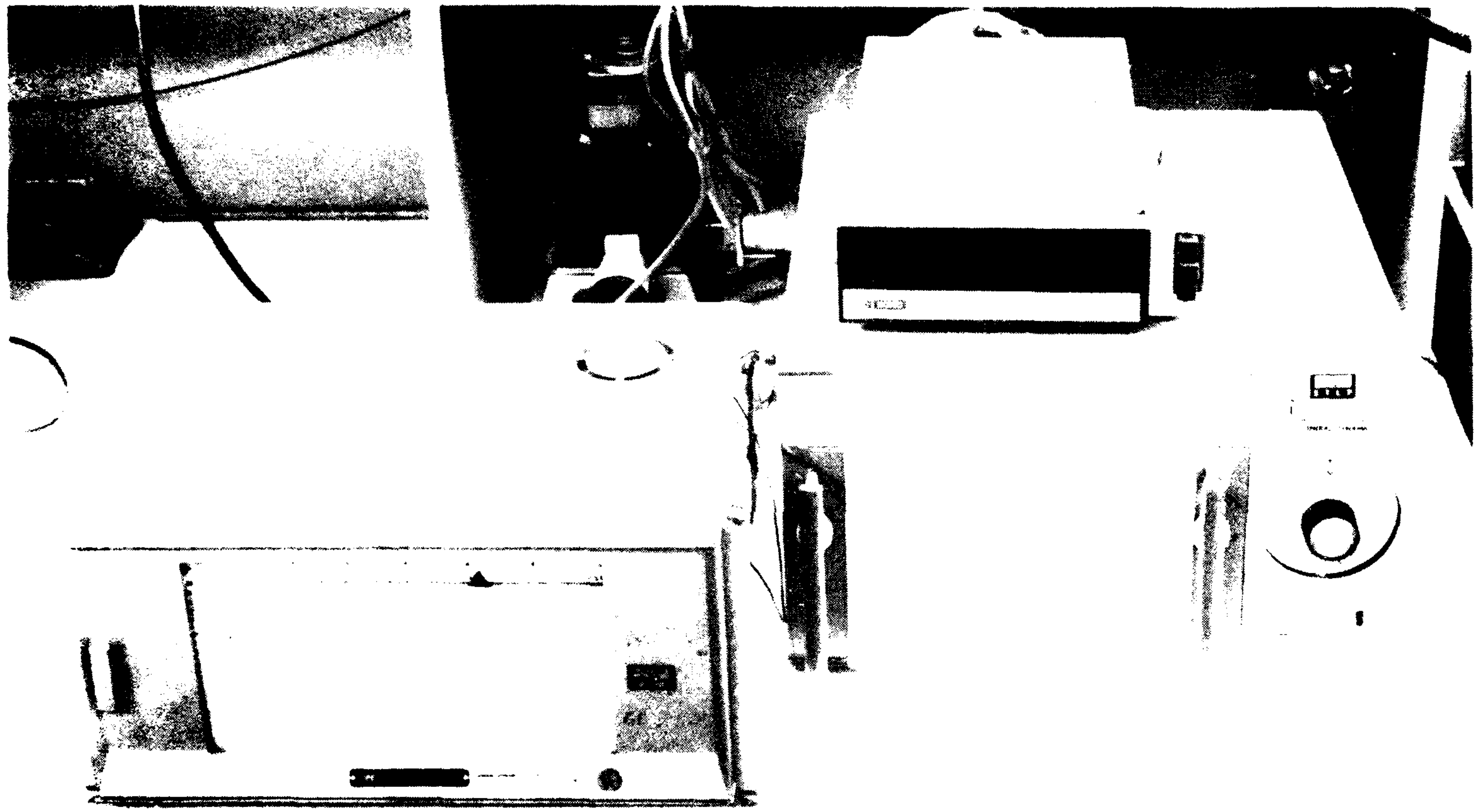
A254368

Figure 3-23. Microsectioned Test Coupon



A254369

Figure 3-24. Environmental Testing at Temperature Extremes - Valox/Electroless Copper Samples



A254370

Figure 3-25. Environmental Testing at Temperature Extremes-Test Set-Up

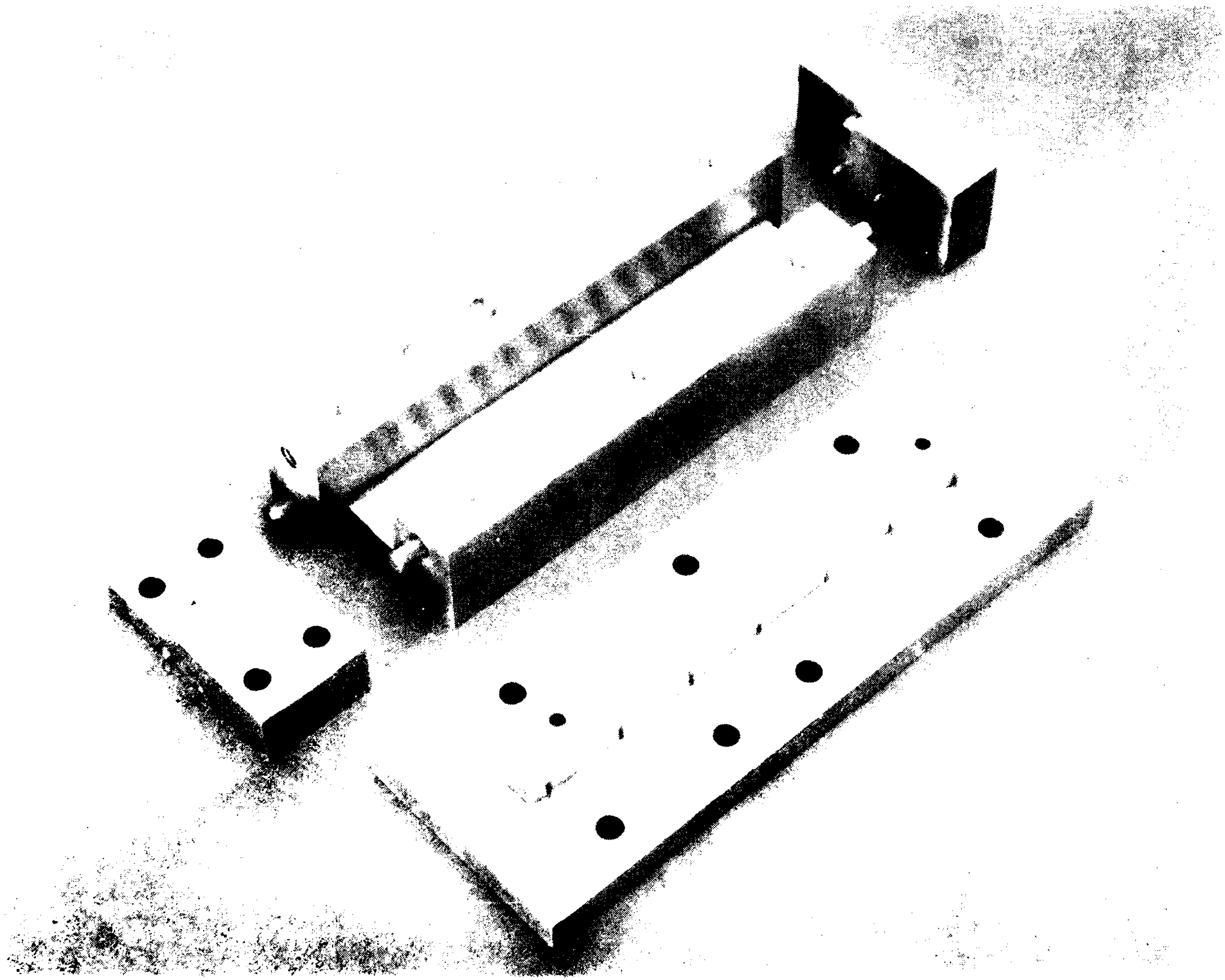


Figure 3-26. Waveguide Filter Cavity Tooling

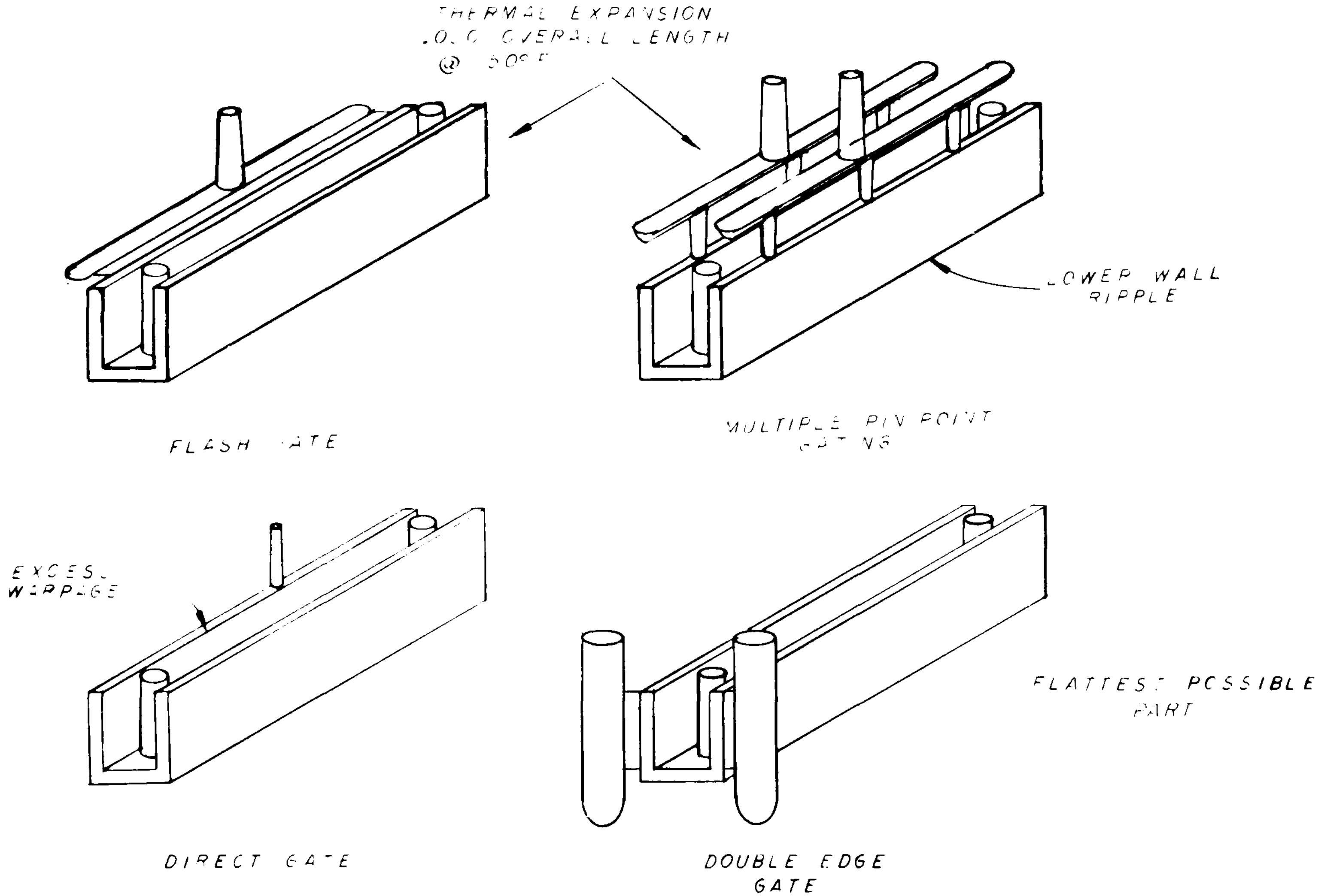
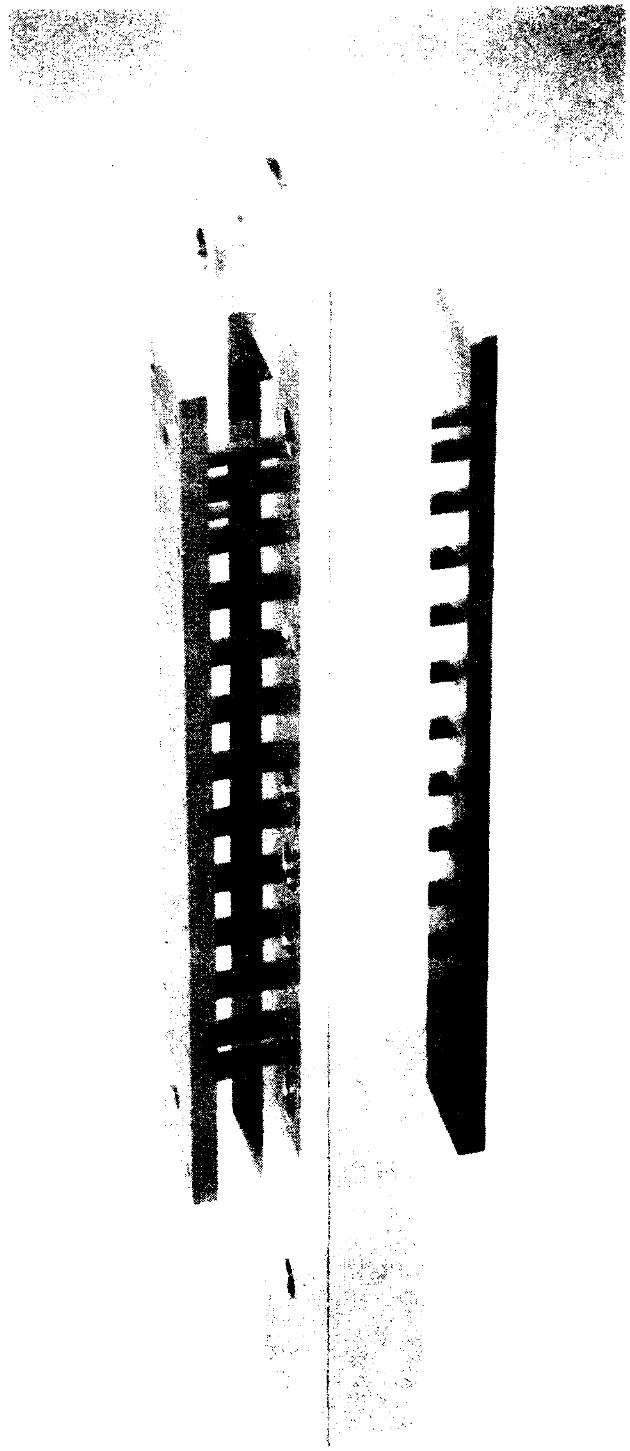
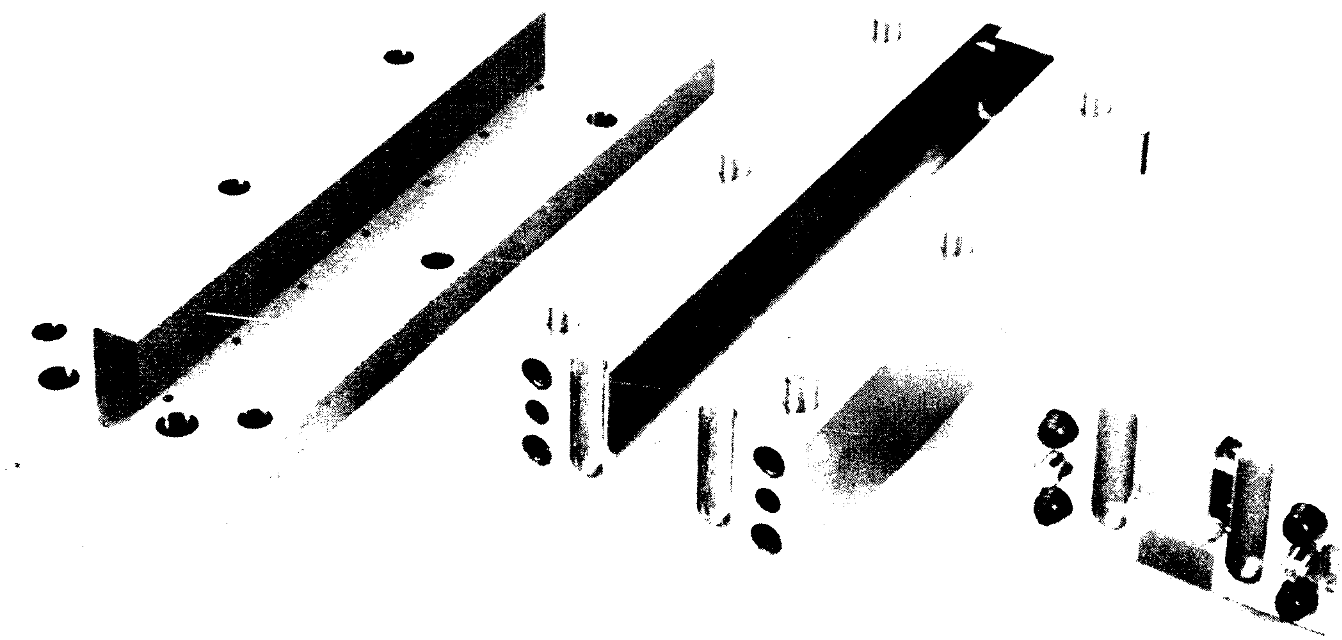


Figure 3-27. Possible Gate Configurations
S-13 Molded Filter



A254372

Figure 3-28. Molded S13 Waveguide
Cap And Valox Ejector



A254373

Figure 3-29. Waveguide Filter Cavity Mold

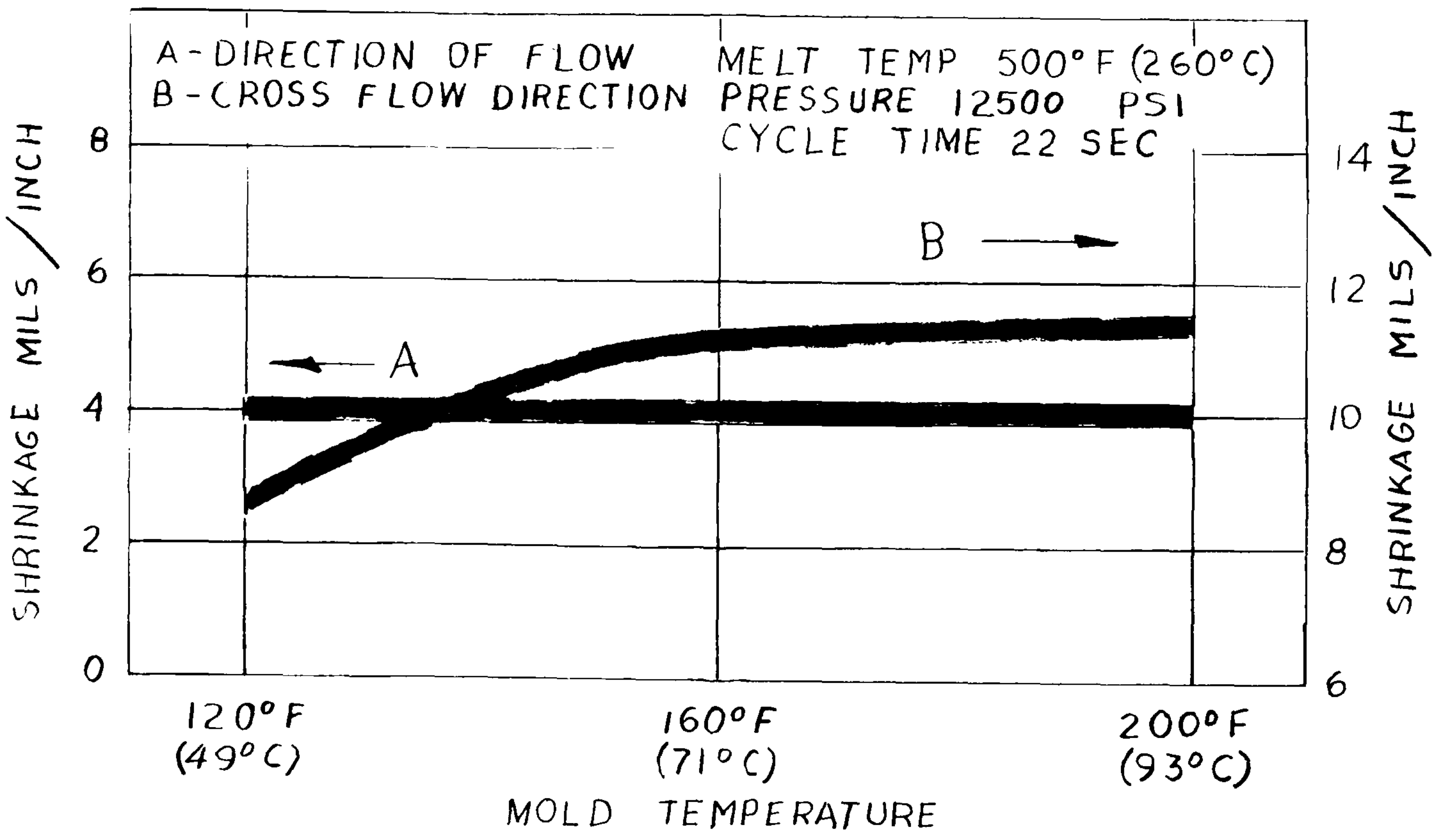


Figure 3-30. Effect of Mold Temperature on Mold Shrinkage (Valox 420-SEO)

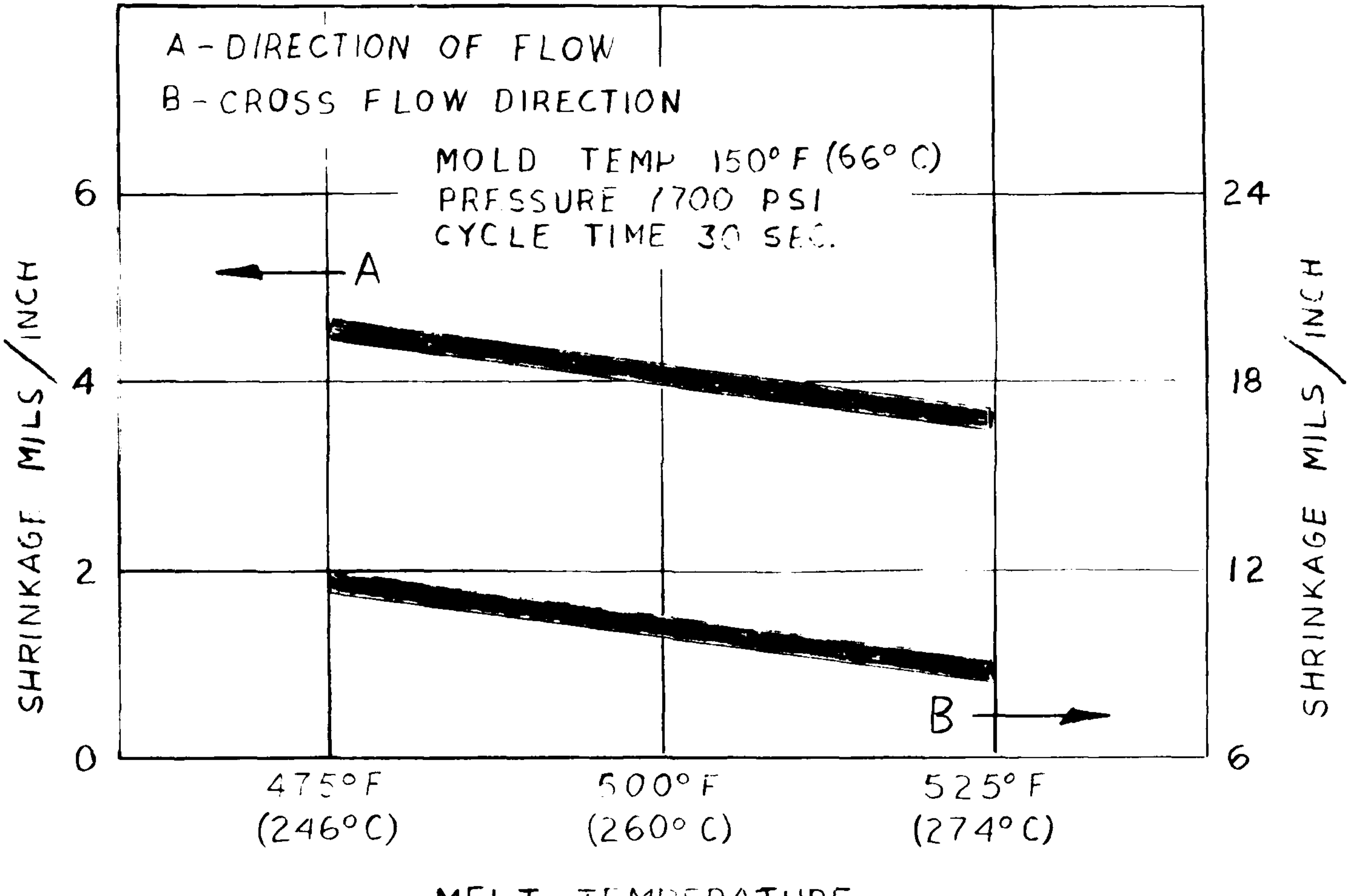


Figure 3-31. Effect of Melt Temperature on Mold Shrinkage (Valox 420-SEO)

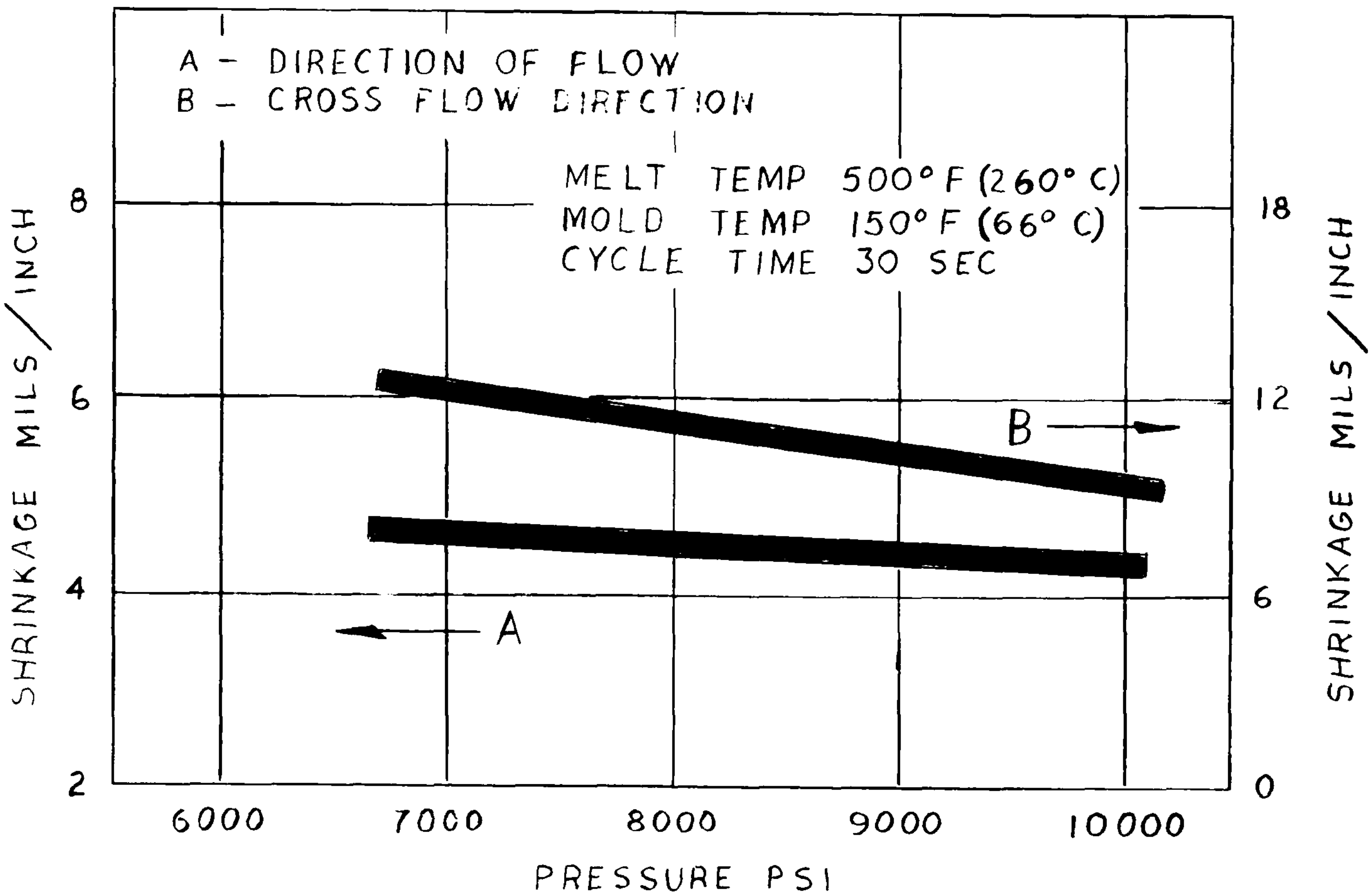


Figure 3-32. Effect of Injection Pressure on Mold Shrinkage (Valox 420-SEO)

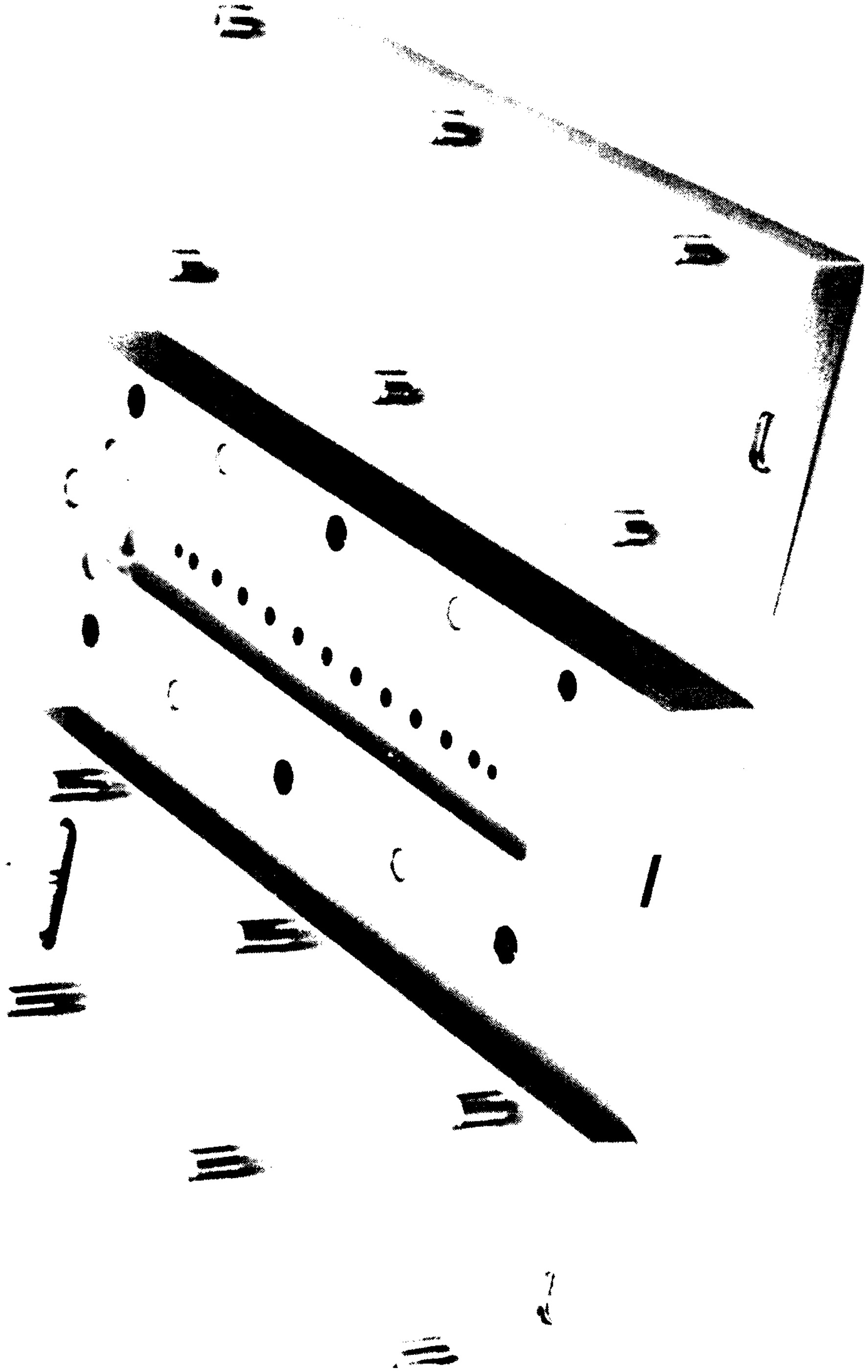
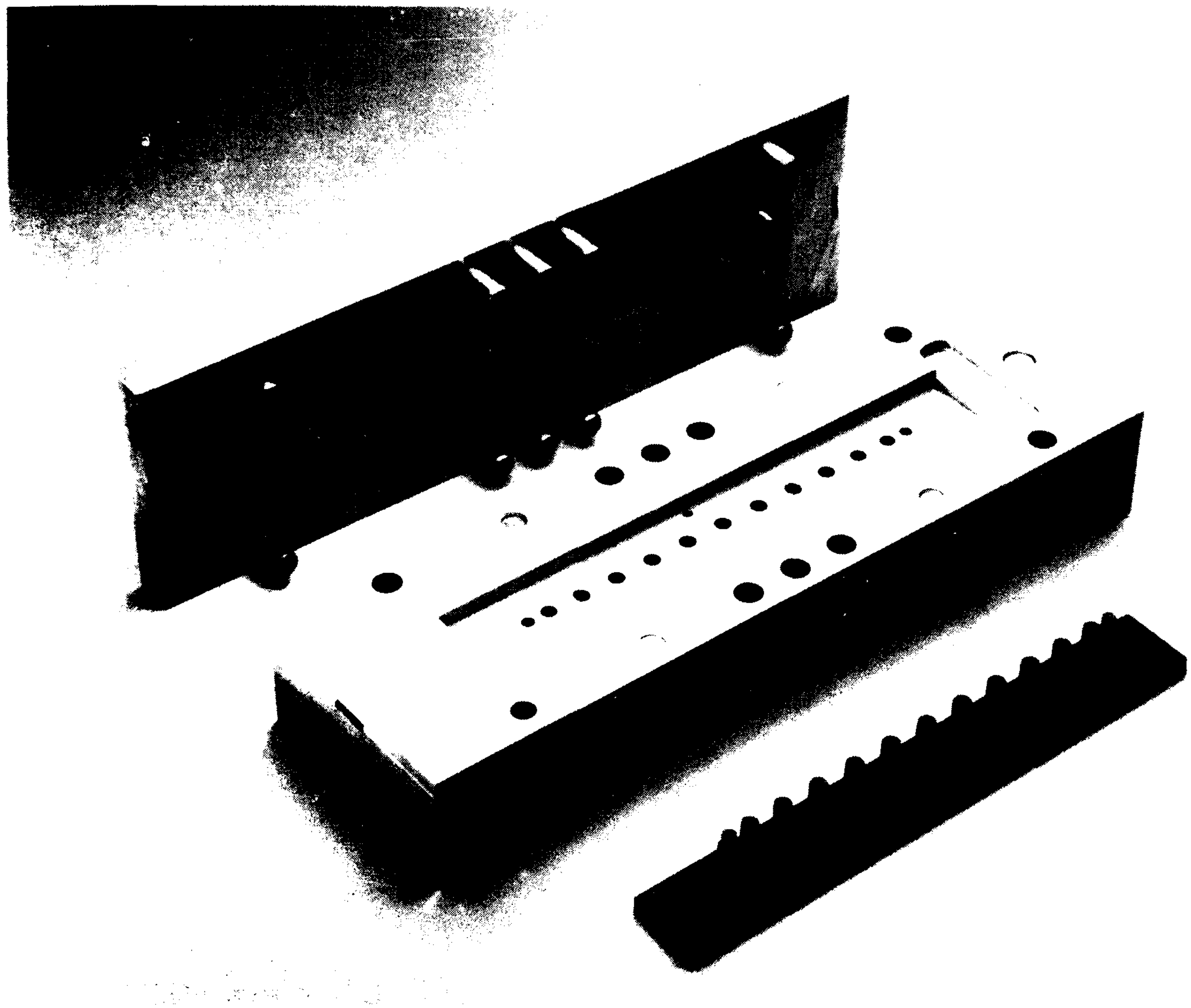


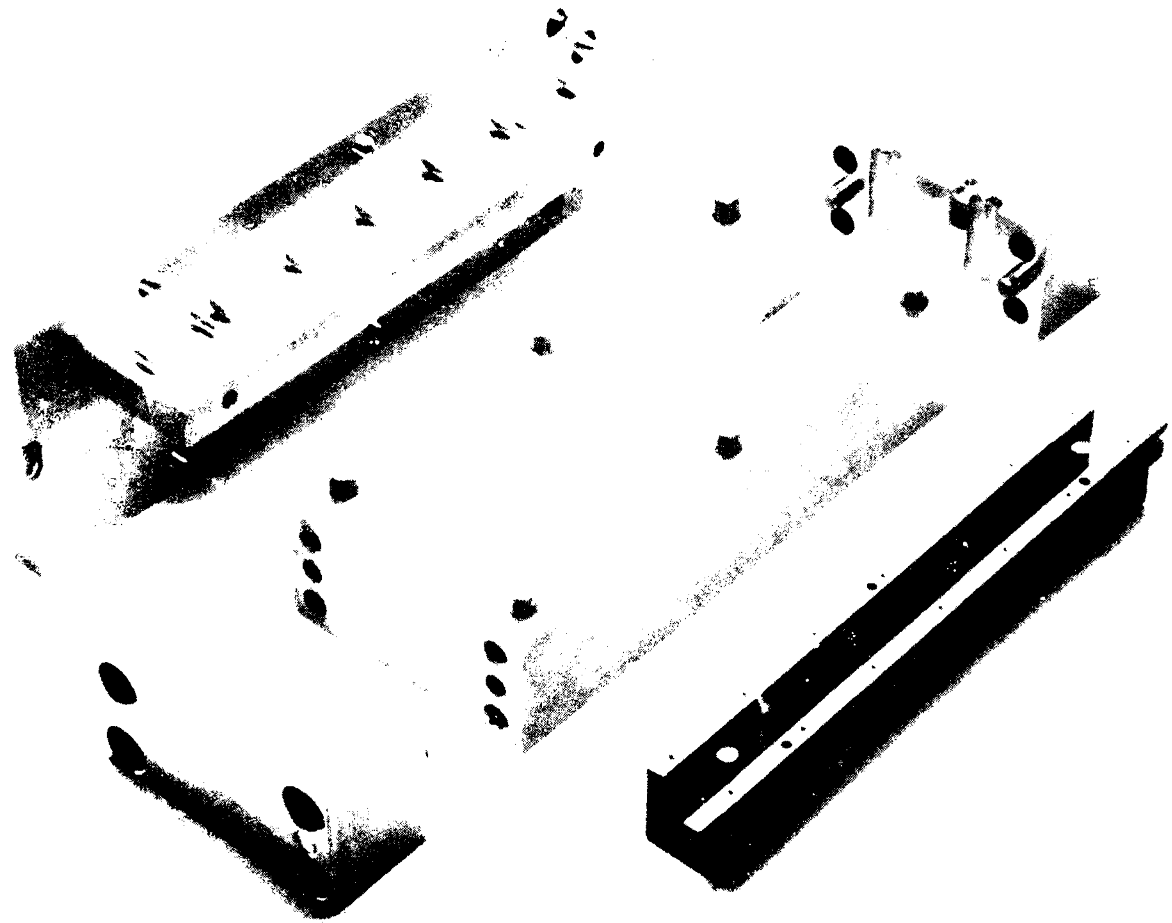
Figure 3-33. Waveguide Filter Cover Mold

A254374



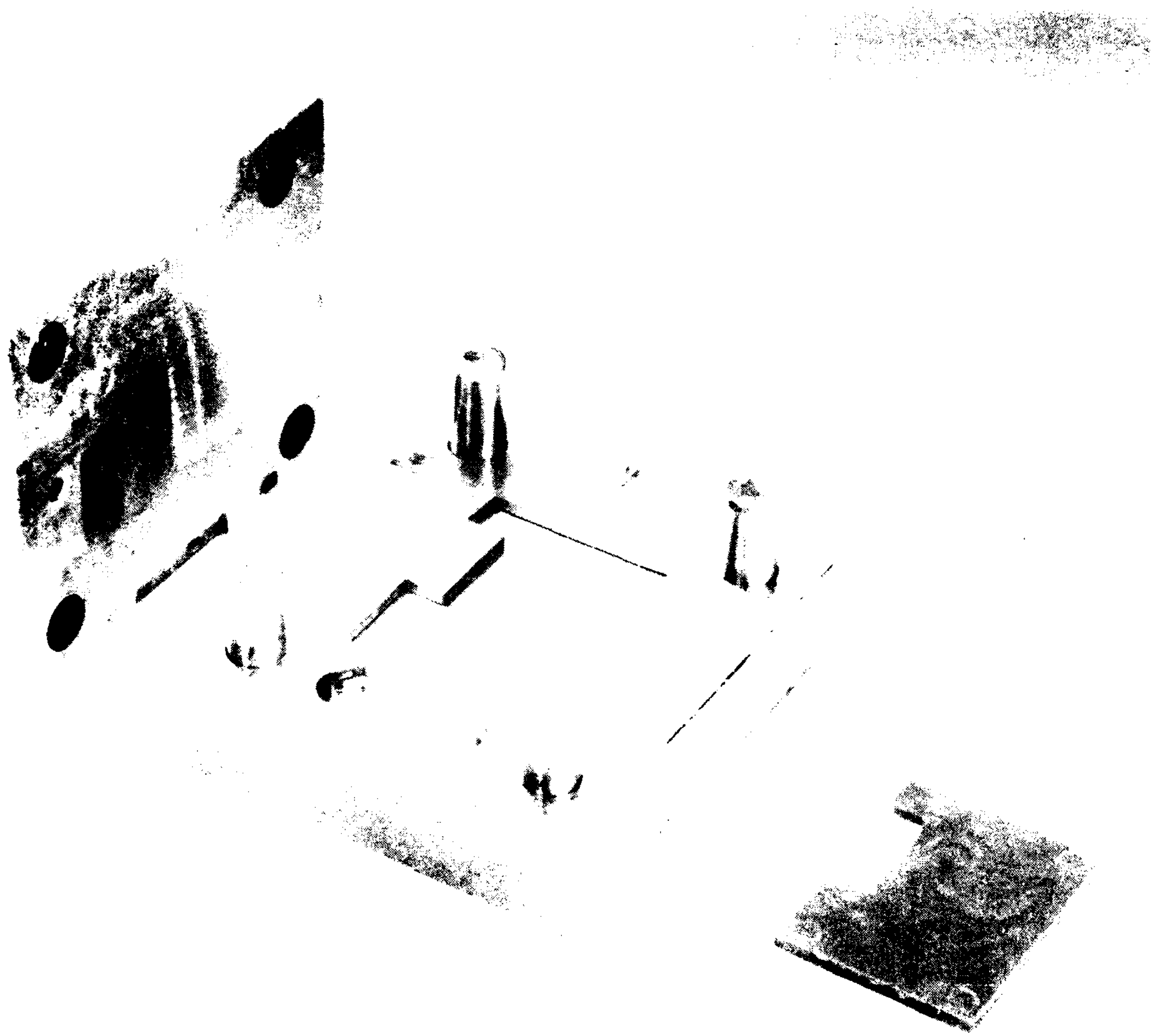
A254375

Figure 3-34. S13 Waveguide Cap Mold and Valox Part



A254376

Figure 3-35. S13 Waveguide Cavity Mold and Valox Part



A2543//

Figure 3-36. S13 Waveguide End Cap Mold and Valox Part

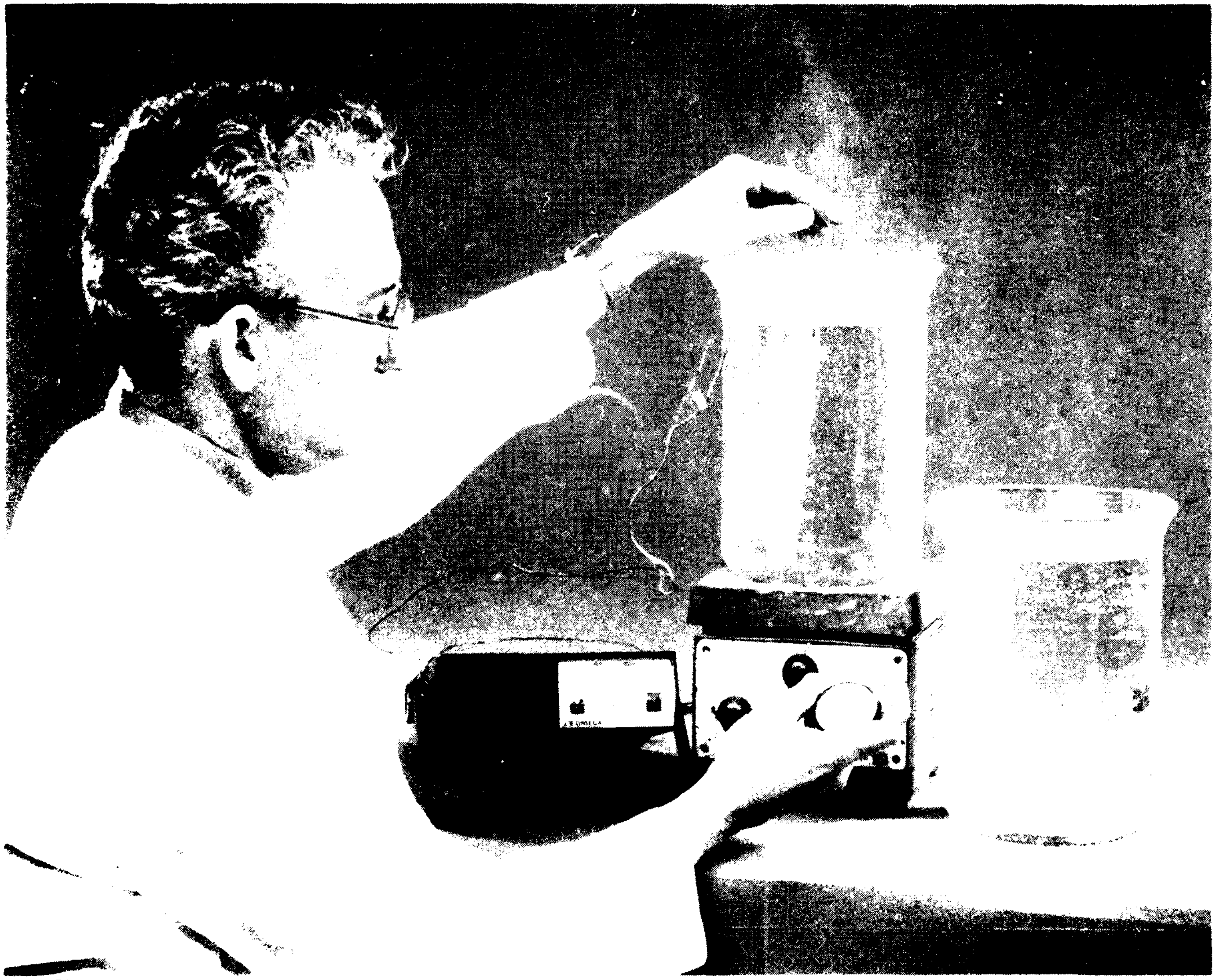

A254378

Figure 3-37. Thermal Shock Cycling - Boiling Water


A254379

Figure 3-38. Thermal Shock Cycling - Ambient

4.0 RESULTS ANALYSIS - INJECTION MOLDED FILTER

The conclusion to this program has yielded excellent results from the standpoint of cost, production, and design reliability:

1. Insertion loss of injection molded filter is extremely low (0.99 db ave versus 1.40 db for machined aluminum filter).

2. The VSWR measurements again show the superiority of the injection molded filter over the metal filter. Average VSWR for the plastic filter was 1.31:1 versus 1.62:1 for the aluminum filter.

3. Attenuation at the stop band also showed significant results. The design specification calls out that attenuation shall be no less than -45 db. Stop band attenuation was -58.24 db for the injection molded filter versus -50.12 db for the metal filter.

4. A weight reduction of 15 grams was realized (aluminum machined filter 150 grams versus injection molded filter 135 grams).

5. A phenomenal cost savings of over 20:1 is a result of the conclusion of this program. The excellent electrical results achieved on this plastic injection molded filter allow this concept to become mandatory if the costly machining operations and large capital outlays necessary to build conventional metal filters are to be avoided. Repeated operator errors in machining metal filters with their stringent dimensional tolerances must be eliminated to prevent the high scrap rate. This can be accomplished with injection molded filters where uniformity and repeatability in dimension and tolerance can be achieved economically by automatic means.

   The total cost of one injection molded waveguide filter was \$157.27 compared with a machined aluminum filter costed at \$3674.42. Complete cost breakdowns for the machined metal and injection molded filters are contained in Tables 3-11 and 3-12, respectively.

CDRL A003
Code Ident 0543
M-24-6-866

ADDENDUM

The environmental-electrical testing of the S13 filters exposed one area which was considered marginal at the upper end of the functional operating specifications for the Close In Weapon System's radar system. At operational temperature extremes (+40°F - +150°F) the frequency response of the filters shifted 60 MHz. Through proper tuning the filters passed the Test Plan requirements, but the results did not provide an adequate performance margin to produce satisfactory production yields. An examination of the Valox 420-SEO material was conducted, it established that the anisotropic coefficient of thermal expansion was the cause for the frequency shift. The fibrous reinforcement became directional during molding, hence α (coefficient of thermal expansion) was decreased in one plane alone.

Although the requirements of the Manufacturing Technology contract were met, it was considered desirable to extend the results to more fully cover this application.

A materials search was conducted to find a resin/filler replacement for Valox 420-SEO to decrease the frequency shift. The three factors examined were; 1) crystalline and amorphous resins for low coefficients of thermal expansion, 2) adaptability to high filler levels, 3) filler materials including fibers, beads, flakes, and powders. Samples and filters were molded of five likely materials for testing α and frequency shifts at operational temperatures.

Five filters were fabricated from the improved material system. These five filters exhibited a frequency shift of 30 MHz from +40°F to +150°F down from 60 MHz of the Valox material. This material system was a polybutylene Terephthalate (thermoplastic polyester) with 35% glass bead and 5% glass fiber. The PBT, a crystalline thermoplastic, was chosen for its retention of strengths at high filler loadings. The glass bead, an isotropic filler, lowered α in all planes. The glass fiber was included to increase mechanical properties. Since Valox 420-SEO is a PBT resin/30% glass fiber system and the new system is PBT resin/35% bead - 5% fiber the metallization and injection molding processes remained identical.

This material is currently being used in the CIWS production filters qualification. An additional eight injection molded filters will undergo environmental-electrical tests per Section II-I of the Test

AD-A093 446 GENERAL DYNAMICS CORP POMONA CA POMONA DIV F/G 13/8
MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS.(U)
APR 80 W L MACTURK N66001-79-C-0022
UNCLASSIFIED NAVSEA-MT-S-617-78 NL

2 OF 4
AD A
093446

A
934

Plan. Performance verification of the new thermoplastic will be under the auspices of the CIWS program office as final production proofing for implementation in that system. The high mechanical properties along with early test data give the program a higher level of confidence in achieving superior filter performance together with satisfactory production yields.

APPENDIX A

CDRL A005
Code Ident 0543
M-24-6-866

APPENDIX A

TEST PLAN

MANUFACTURING TECHNOLOGY PROGRAM

FOR

MICROWAVE COMPONENTS

CONTRACT N66001-79-C-0022 WJC

Introduction

This test plan is being submitted in compliance with the requirements of Contract N66001-79-C-0022WJC. "Microwave Component Manufacturing Technology" specifically dealing with a manufacturing process to produce plated injection molded waveguide filters.

The test plan defines the scope of the tests required to insure that the hardware produced by the demonstrated manufacturing process meets all applicable technical, functional, and performance criteria. It presents details as to which tests are to be performed, what procedures will be used to conduct the tests, what constitute the criteria for test results acceptance, who has the responsibility for conducting the tests, and the schedule for accomplishing the tests.

Objective

(a) To fabricate a series of similar plated microwave injection molded post waveguide filters operating in the S band region to the dimensions specified by the CIWS engineering drawing and to the fabrication process specifications established in this program, for the purpose of performing acceptance qualification tests.

(b) To formulate and document a test plan and procedures to determine the structural, electrical, and environmental properties of this 13 post S band microwave filter, and to verify that it meets all specifications consistent with the CIWS system requirements. All test data is to be documented and submitted as part of the final report along with a complete description of the corresponding manufacturing process (Development Process Specification).

(c) The test plan outlining the test results and the appropriate department group at General Dynamics conducting the tests will appear as appendices at the end of the final report.

PREPARED BY: W. L. MacTurk
W. L. MacTurk
Program Director,
General Dynamics, Pomona Div.

CONCURRED BY: G. E. Stanley
G. E. Stanley
System Development and
Sub Contracts
Phalanx Program Office

APPROVED BY: M. C. Abrams Jr.
M. C. Abrams, Chief
Advanced Manufacturing Technology
General Dynamics, Pomona Div.

ACCEPTED BY: John Markall
John Markall
Program Monitor
Naval Ocean Systems Center

A. <u>Test Plan</u>

I. <u>Testing Requirements for an Injection Molded Plastic Microwave Band Pass Filter Operating at S Band Frequencies</u>

B. <u>Physical Properties of Injection Molding Plastic - Valox 420 SEO Coupons</u>

1. Tensile Strength
2. Compressive Strength
3. Flexural Modulus
4. Thermal Conductivity of Valox 420 SEO Plastic
5. Thermal Expansion of Valox 420 SEO Plastic

C. <u>Electroless Plating Properties of Valox 420 SEO Coupons</u>

1. Copper Adhesion to Coupons
2. Copper Thickness
3. Copper Uniformity
4. Surface Finish

D. <u>Thermal Shock</u>

1. Plating Integrity of Coupons after Thermal Shock

E. <u>Tooling Molds - Injection Molding</u>

1. Design of Steel Waveguide Cavity Mold
2. Design of Steel Cap and Post Mold
3. Fabrication of Steel Waveguide Cavity Mold
4. Fabrication of Steel Cap and Post Mold
5. Dimensional Accuracy of Steel Waveguide Cavity Mold
6. Dimensional Accuracy of Steel Cap and Post Mold

F. <u>Dimensional Tolerance Accuracy of Injection Molded Filter</u>

1. Post Diameters
2. Post Separations
3. Post Length
4. Post Perpendicularities
5. Tuning Posts to Tuning Screws - Concentricity.
6. Waveguide Dimensions
7. Surface Finish

G. Copper and Gold Plating of Injection Molded Filters

1. Dimensional Accuracy as referenced in Section II-G-1.
2. Surface Finish as referenced in Section II-G-2.

H. Thermal Shock - Plated Injection Molded Filters

1. Thermal Shock Cycling - Water Immersion
2. Thermal Shock Cycling - Temperature Extremes

I. Functional Testing of Plated Injection Molded Filters

1. Electrical Testing of Filters
2. Environmental Testing of Filters

II. Test Procedures on Injection Molded Waveguide Post Filters

B. Physical Properties of Injection Molding Plastic - Valox 420 SEO Coupons

General Electric's Valox 420 SEO, a thermoplastic polyester resin reinforced with a 30% glass fiber component results in increased thermal properties, strength, stiffness, and dimensional stability over unreinforced grades of thermoplastics.

This reinforced glass thermoplastic is an excellent candidate for this program.

Physical properties called out in Section I-B will be tested to verify the vendor's numbers and should meet the following.

1. Tensile Strength $>$ 16000 psi. (Minimum 5 test coupons)
2. Compressive Strength $>$ 18000 psi. (Minimum 5 test coupons)
3. Flexural Modulus $> 1 \times 10^6$ psi. (Minimum 5 test coupons)
4. Thermal Conductivity — 1.3 $BTU/Hr/Ft^2/in/^oF$
5. Coefficient of Thermal Expansion — 1.3 to 1.5 $in/in/^oF \times 10^{-5}$ (Mold Direction)

C. Electroless Plating Properties of Valox 420SEO Coupons

1. Copper adhesion to test coupons (minimum 3 test coupons). Peel strength shall be greater than 2.5 lbs per in/in when measured on a tensilometer to Mil-Std-P-55617.

2. Copper thickness. (Minimum 6 test coupons) Copper thickness including gold flash shall be 0.0008" ± 0.0002" as cross sectioned for metallographic samples.

3. Copper uniformity. (Minimum 6 test coupons)
   Copper uniformity as to thickness and surface smoothness shall not vary above or below the dimension and tolerance given in Section II-C-2 at any given point on the test coupon.

4. Surface Finish (minimum 6 test coupons) shall be no greater than $\sqrt[63]{}$.

D. Thermal Shock

1. Plating Integrity of Coupons after Thermal Shock (minimum 6 test coupons).
   No delamination or blistering of the copper from the coupons is allowed after testing as follows in a controlled thermal chamber and cycled for 10 cycles

$$\left.\begin{array}{l} -40^{o}F - 30 \text{ minutes} \\ 75^{o}F - 5 \text{ minutes maximum} \\ 160^{o}F - 30 \text{ minutes} \\ 75^{o}F - 5 \text{ minutes maximum} \end{array}\right\} \text{1 Cycle}$$

E. Tooling Molds - Injection Molding

The engineering drawings which specify a machined metal filter with machined tuning posts, dip brazed into the waveguide cap reflect dimensional tolerances of a stringent critical nature due to more than 50 machining and assembly operations required to produce this filter. These dimensional tolerances in certain cases may be relaxed in the injection molded filter since the waveguide cavity, tuning posts, waveguide cap, mounting screw holes, are all injection molded in a single shot operation. Consequently dimensions in some areas of the molded filter will not follow those of the metal filter but where critical tolerances affect electrical performance these conditions will be met.

Tooling molds will be checked dimensionally and will reflect mold shrinkage and plating thickness tolerances. Dimensions where required will be held to the tolerances quoted under Section II-F.

F. Dimensional Tolerance Accuracy of Injection Molded Filter

1. Post Diameters (minimum of 5 filters). Diameters will be held to a dimensional tolerance of ± .001.

2. Post Separations. (Minimum of 5 filters). Separation between tuning posts will be held to a dimensional tolerance of ± 0.003".

3. Post length. (Minimum of 5 filters). Post length will be held to a dimensional tolerance of ± 0.002".

4. Post Perpendicularities. (Minimum of 5 filters). Posts must be perpendicular to waveguide cap within ± 0.003".

5. Concentricity of Tuning Posts to Tuning Screws (Minimum of 5 filters). Must be held within 0.002".

6. Waveguide Dimensions (Minimum of 5 filters). Must be held to a dimensional tolerance of ± .005".

7. Surface Finish. (Minimum of 5 filters). Surface finish must be better than $\overset{63}{\checkmark}$.

G. Copper and Gold Plating of Injection Molded Filters

1. Dimensional Accuracy. (Minimum of 5 filters) These will reflect the same tolerances called out in Section II-F, 1, 2, 3, 4, 5 and 6. Copper thickness including the gold flash for corrosion purposes will have a dimension and tolerance of 0.0008" ± 0.0002".

2. Surface Finish. (Minimum of 5 filters) As referenced in Section II-F-7 surface finish will be less than $\overset{63}{\checkmark}$.

H. Thermal Shock - Plated Injection Molded Filters

1. Thermal Shock Cycling - Water Immersion (Minimum of 3 filters) This harsh test will consist of 10 cycles. One cycle will consist of immersing a filter into boiling water for 10 seconds then removing the filter and immersing it into room temperature running water for 10 seconds, and repeating these operations continuously for ten cycles. Each filter will then be examined for plating defects such as (a) longitudinal cracking of the copper surface, (b) blistering, or (c) delamination. No defects allowed on a, b or c.

2. Thermal Shock Cycling - Temperature Extremes (Minimum of 3 filters). This will be identical to the thermal shock cycling as detailed in Section II-D-1. No delamination or blistering of the gold/copper from the plastic substrates of the filters allowed.

I. <u>Functional Testing of Plated Injection Molded Filters</u>

1. <u>Electrical Testing of Filters (Minimum of 3 filters)</u>

Filters will be tested on an Automatic Network Analyzer HP 8542 and must meet the following requirements.

(a) Center frequency F_c = 1/5 (Fo - 1600) MHz

(b) Pass Band $F_c \pm 125$ MHz

(c) VSWR within Pass Band 1.8:1 maximum

(d) Insertion loss within Pass Band 2db maximum

(e) Attenuation at F_c + 220 MHz 45 db minimum

(f) Attenuation at F_c - 220 MHz 45 db minimum

2. *<u>Environmental Testing of Filters (Minimum of 3 filters)</u>*

(a) <u>Temperature</u>

The filter shall survive with no deterioration a non-operating temperature range from -40°F to 160°F and an operating temperature range of $+40^\circ$F to $+150^\circ$F without degradation of the requirements specified/in II-I-1, a,b,c,d,e, and f.

(b) <u>Shock</u>

Three shocks in each direction shall be applied along three mutually perpendicular axes of the filter (total of 18 shocks). The shock pulse shape, acceleration, and duration will be a half sine wave, of 40 g's with a 11 millisecond duration. (Mil-Std 810C Method 516.2, procedure 1.)

(c) <u>Random and Sinusoidal Vibration</u>

A random vibration of 30 minutes each in the three mutually perpendicular axes of the filter, of 5.4 g's RMS at frequencies between 20Hz to 2000 Hz corresponding to curve AE figure 514-2-5 procedure VII of Mil-Std-810C. Also a sinusoidal vibration of 30 minutes each in the three mutually perpendicular axes of the filter to curve P at a peak acceleration level of 5 g's as shown in Figure 514-2-5, Mil-Std-810C.

(d) Humidity

The filter must be capable of operating in a relative humidity condition of 95% to Mil-Std-810C 3.4 procedure IV.

III. Criteria For Successful Test Determination

Where applicable all tests conducted will meet the requirements specified in the Design Instruction Environments D1-444-A-002A Phalanx Close In Weapon System.

Testing requirements for the S13 plastic molded filter will conform to the testing criteria of the S13 machined metal filter and are contained in M6-223-9-21-109 "A". This engineering document outlines the electrical test procedure used to determine the satisfactory performance of the S13 comb filter. Specifications for this filter are listed in M6-223-24.46-90"B" and the frequency F_o is defined in M6-223-24.13-301"B". M6-223-9.21-109"A" also identifies the test equipment used to electrically test the filter.

Document M6-223-24.46-90"C" outlines the signal generator package requirements affecting the S13 filter and the dynamic input and output voltages, power levels frequency ranges, and signals which define successful operating criteria.

Document M6-223-24.13-110"A" defines the testing procedures for successful operation for environmental testing of the filter along with the appropriate MIL Standards outlining these tests.

Plating thickness and adhesion must meet the test requirements called out in Section II-C of this test plan. Mechanical properties of the injection molded plastic must meet the test criteria detailed in Section II-B of the test plan.

Dimensional tolerance structure of the filter criteria of section II-F&G of the test plan.

IV. Test Responsibility

A. The Phalanx Program Office surveillance of the testing procedures outlined in Section II will be under the direction of Mr. V. A. Ferradino of the Quality Assurance Group Dept. 27.

B. The mechanical properties called out in Section II-B, 1, 2, and 3, will be conducted by the Quality Assurance Group Dept. 27 under the supervision of Mr. Joe Harrel. Mr. Harrel will also have the responsibility of Quality Assurance testing of Section II-C, 1, 2, 3, and 4,

Testing in Section II-H, 1, and 2, will be conducted by Advanced Manufacturing Technology under the direction of Dr. M. C. Abrams, but these tests will be verified by Quality Assurance under the supervision of Mr. Harrel. Testing of the items under Mr. Harrel's department will be conducted by Mr. Frank Sawyer of Department 6-125.

C. Tooling molds and dimensional accuracy of the molded filters called out in Sections II-E, II-F, and II-G will be under the supervision of Mr. W. Olson, Quality Assurance Group Dept. 27.

D. Thermal conditions specified in Section II-B items 4 and 5 will be conducted by Advanced Manufacturing Technology under the direction of Dr. M. C. Abrams. Tests also conducted by Manufacturing Technology are defined in Section II-D with Quality Assurance supervision under Mr. Joe Harrel.

E. Functional Testing of the plated injection molded filters will be conducted by the Engineering Department Group 6-223 under the direction of Mr. R. M. Haner. These tests which include electrical and environmental testing of the filters are defined in Section I items 1(a), (b), (c), (d), (e), and (f), and items 2 (a), (b), (c), and (d).

   Test equipment and results will be monitored for Quality Assurance under the direction of Mr. Joe Harrel.

V. <u>Time Schedule</u>

TASK	M	J	J	A	S	O	N	D	J	F
1. Tensile Strength of Valox 420 SEO	—									
2. Compressive Strength of Valox 420 SEO	—									
3. Flexural Modulus of Valox 420 SEO	—									
4. Thermal Conductivity of Valox 420 SEO	—									
5. Coefficient of Thermal Expansion of Valox 420 SEO	—									
6. Copper Adhesion (Peel Strength) of Valox 420 SEO	—	—								
7. Copper Thickness of Valox 420 SEO	—	—								
8. Copper Uniformity on Valox 420 SEO		—								
9. Surface Finish of Plated Copper on Valox 420 SEO		—								
10. Thermal Shock Tests on Plated Valox 420 SEO		—	—							
11. Tooling Molds - Dimensional Accuracy			—	—						
12. Dimensional Tolerance Accuracy - Injection Molded Filter				—						
13. Dimensional Accuracy - Plated Injection Molded Filter					—					
14. Thermal Shock - Plated Injection Molded Filter						—				
15. Functional Testing of Plated Injection Molded Filter										
(a) Electrical							—			
(b) Environmental								—		
16. Final Report								—	—	—

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX B

APPENDIX B

PHYSICAL PROPERTIES OF INJECTION MOLDING

PLASTIC-VALOX 420 SEO COUPONS

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 26 June 1979

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR TENSILE STRENGTH, COMPRESSIVE STRENGTH, AND FLEXURAL MODULUS.

The material was tested on an Instron Universal Testing Machine Model #TTD. The material meets the requirements of the Test Plan M-24-6-866 Sections II-B-1, II-B-2, and II-B-3. Quality Assurance Report R225925 is attached to this certificate of compliance and delineates the data obtained and the method of testing. Calibration on equipment is not due until 21 February 1980.

DESCRIPTION			
General Electric's Injection Molded Valox 420-SEO			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	P0177771A	
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: [signature] : TEST ENGR.
(AUTHORIZED SIGNATURE)

NAME: H. J. Hassel

TITLE: Chief Of Inspectors
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

(0) CIRCLE REPORT TYPE: A B D Hardware

NO. R225925 1

AA
- 1) Cat:
- 2) Report Facility: PD
- 3) Init Dept: 24-6
- 4) Contract Cd:
- 5) Level:
- 6) Cst Ctr:
- 7) TDR Code:
- 8) Emp No: 12378
- 9)
- 10) Task No. or AWO:
- 11) Ref Orig QAR:
- 12) T.E. No. & Dash No:
- 13) TFCAR Cd:
- 6A: A
- 15) Item Name:
- 16) Item Part No: VAlox 420-SEO
- 17) Serial No:
- Cont? Y Page A
- 18) Test Type:
- 19) New Work? Y N
- 20) Supplier Name: General Electric

EA
- 23) Test Procedure, Method:
- 24) Shop Order, Op. No: /
- 25) Foreman (Print):
- 26) Date Initiated: Day 11, Mo 06, Yr 79
- 27) Time:

FA
- 28) MRB Reqd? Y
- 29) No. Insp:
- 30) No. Rej:
- 31) Lot Qty:
- Sample Qty Re:
- 32) Govt Furn? Y
- 33) Task No.:
- 34) Priority:

DA 21) Discrepancy or Requirement

#1

Test per Test Plan M-24-6-866

Contract N66001-79-C-0022 WJC

Supp Used? Y
Split Rcvd? Y

SC
- 87) Resp. Dept:
- 74) C/A Status: NACK
- 75) NC AR:
- 72) C/A Assigned to: –
- 81) CAU-1:
- 77) D.C-1:
- 22) Control Grp:

Fix STAMPS: 46) SHOP | 47) INSP | 48) CUST

GA 45) Fix or Disposition (Recommended Disposition)

Idfy Parts with QAR No.? Y
Disp. Plan Suppr? Y
QAR Split? Y
TRR Supr? Y

HA
- 96) Rec. Rpt No: 9D6668
- 97) Purch. Order No: PO177771 A
- 98) Group:
- 99) Supplier ID No: D-769

SC
- 35) Other Dispos:
- 36) No. Rwk:
- 37) No. Rpr:
- 38) No. Scrap:
- 39) No. Rtn:
- 40) Std Rpr? ABC
- 41) Y N
- 42) AR Conform? Y N
- 43) $ Cost:
- 44) Exp. Of:

QA
- 100) Disp. Qual Rep:
- 101) Engr Rep:
- 102)
- 103) Cust. Rep:
- 104) Buyer Rep:
- 105) Disp. Date: Day Mo Yr

CLIP OUT/DETAILS REMOVED-REPLACED-SCRAPPED

REF STEP	60) EFFECT. DFL NAME	61)	62) PART NO	63)	64)	65)	66) REPLACEMENT NAME	67)	68)
KA									
KB									
KC									
KD									
KE									
KF									

NA
- Labor M.H: Hours Tenths
- Reviewed by:
- Closed: Day Mo Yr 27 06 79
- Est. $ Cost:
- QC Insp: GD 260
- SC

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hardware

NO. R225925 B

70) Failure Diagnosis / Analysis

Tensile Strength (ASTM D-638)	Sample	Strength
	0	$1.76 \cdot 10^4$
	1	$1.71 \cdot 10^4$
	2	$1.82 \cdot 10^4$
	3	$1.74 \cdot 10^4$
	4	No Test
	5	No Test
	6	$1.82 \cdot 10^4$

Compressive Strength (ASTM D-695)	Sample	Strength
	1	$2.05 \cdot 10^4$
	2	$2.11 \cdot 10^4$
	3	$2.17 \cdot 10^4$
	4	$2.26 \cdot 10^4$
	5	$2.32 \cdot 10^4$
	6	$2.16 \cdot 10^4$

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

118) CORRECTIVE ACTION

Flexural Modulus (ASTM D-790)	Sample	Modulus
	1	$1.13 \cdot 10^6$
	2	$1.19 \cdot 10^6$
	3	$1.14 \cdot 10^6$
	4	$1.21 \cdot 10^6$
	5	$1.17 \cdot 10^6$

[signature] 6-25-79

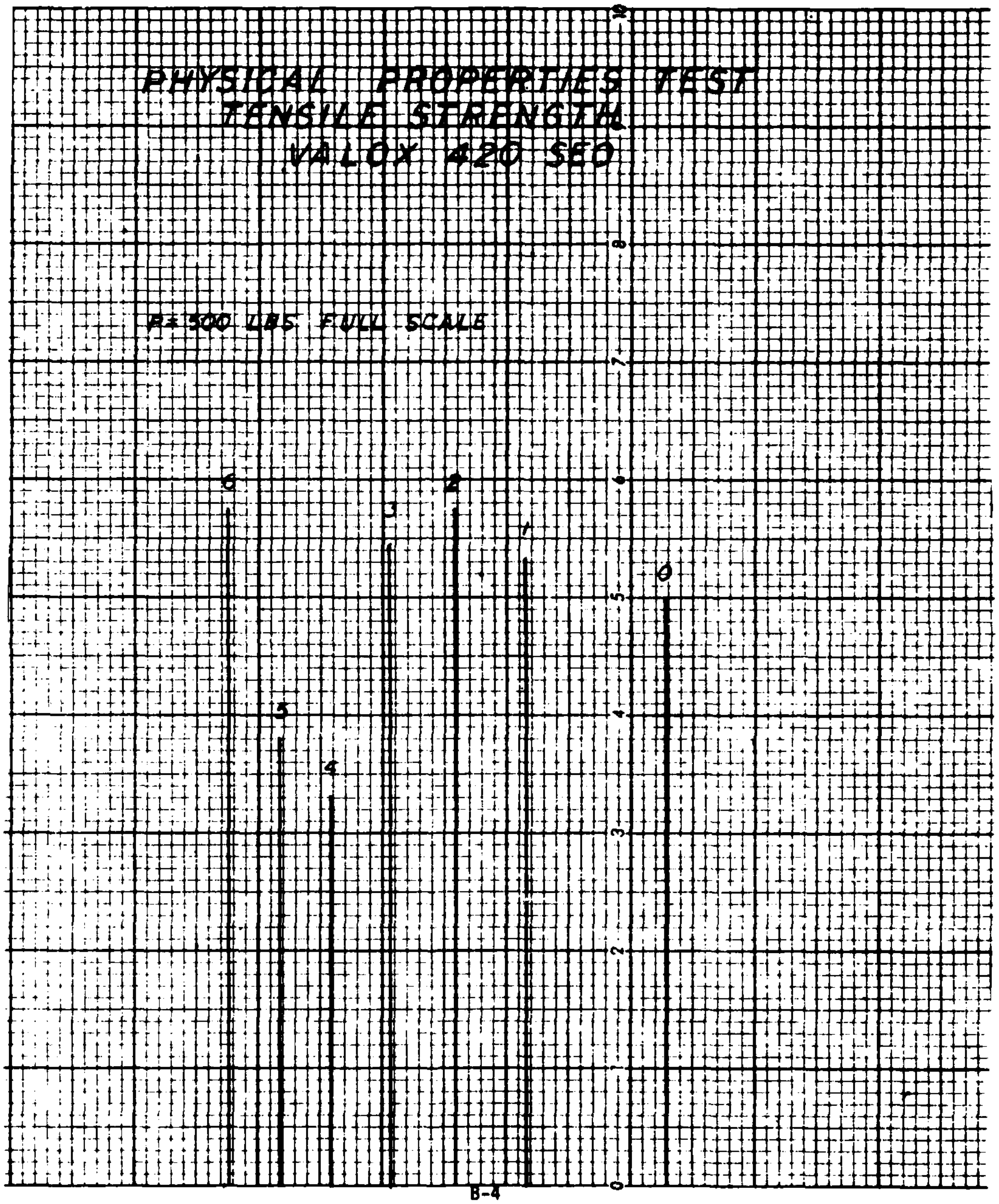
Suppl used? Y

76 CAT Y

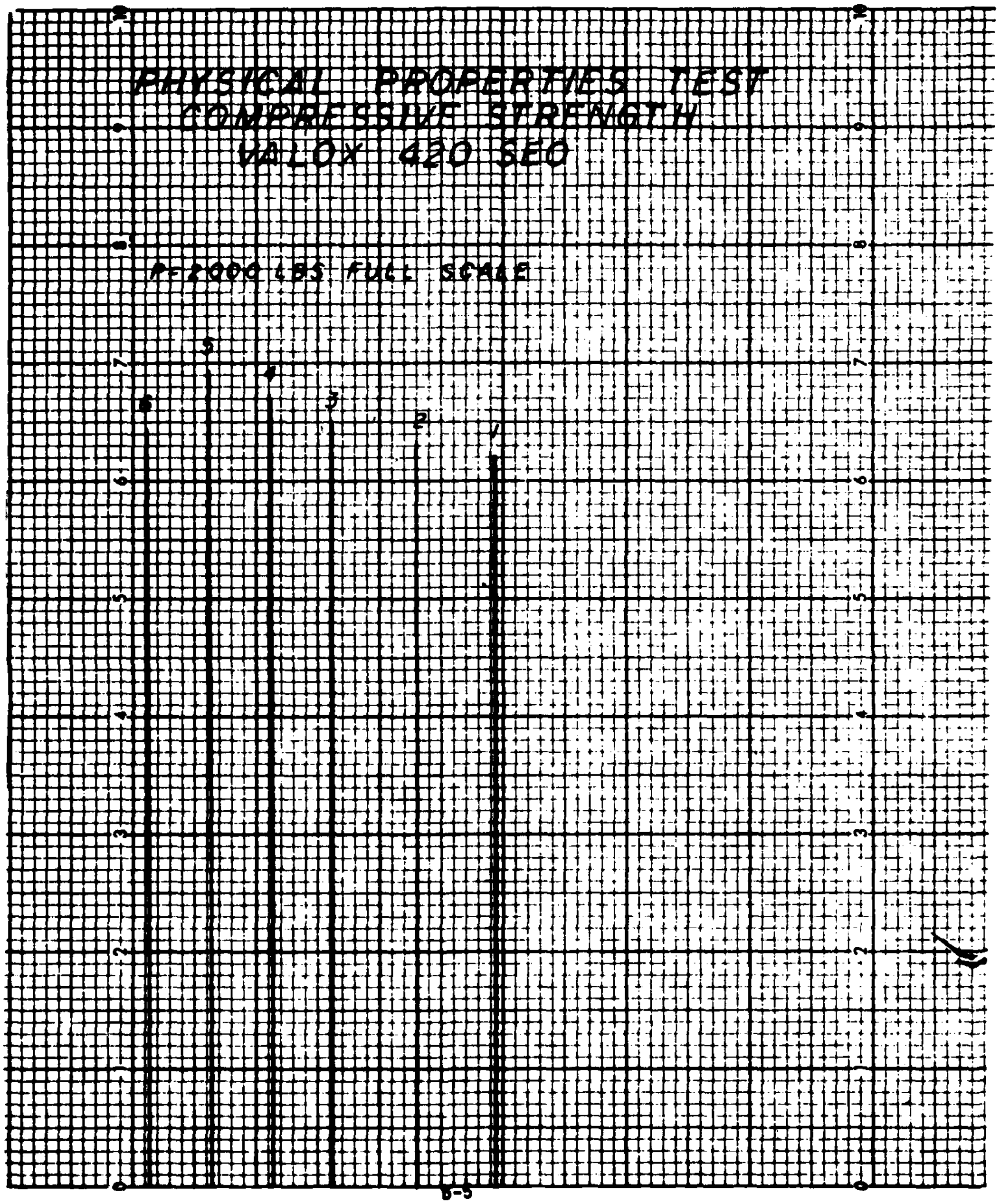
CHANGE OR UPDATE THE FOLLOWING DATA BLOCKS AS INDICATED

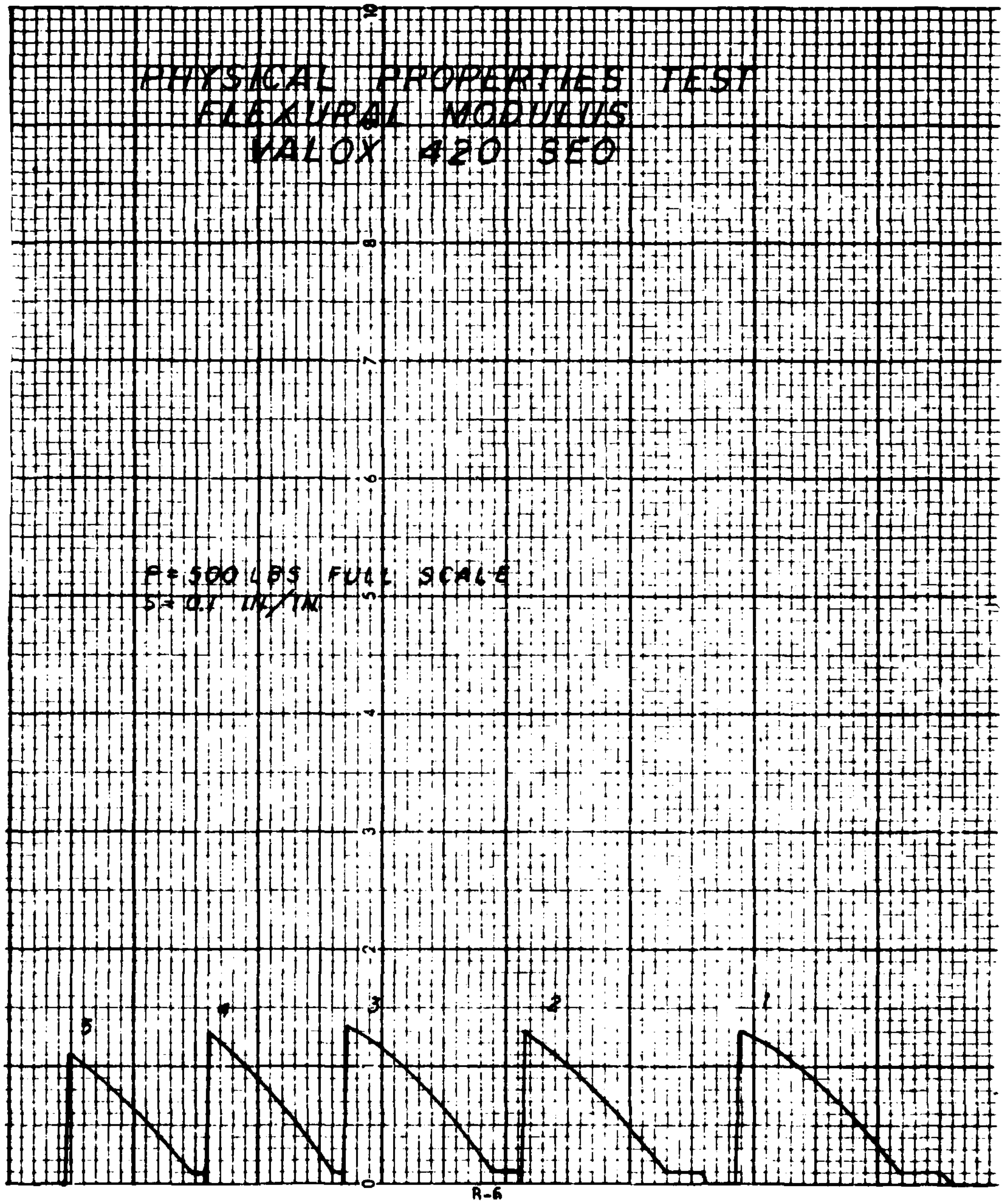
SC

MFG Y


PHYSICAL PROPERTIES TEST
TENSILE STRENGTH
VALOX 420 SEO
P=500 LBS FULL SCALE
6
5
4
3
2
1
0

B-4


PHYSICAL PROPERTIES TEST
COMPRESSIVE STRENGTH
VALOX 420 SEO
P=2000 LBS FULL SCALE
6
5
4
3
2
1
B-5


PHYSICAL PROPERTIES TEST
FLEXURAL MODULUS
VALOX 420 SEO
P=500 LBS FULL SCALE
S=0.1 IN/IN
10
8
7
6
5
4
3
2
0
5
4
3
2
1
B-6

APPENDIX C

APPENDIX C

ELECTROLESS PLATING PROPERTIES OF

VALOX 420 SEO COUPONS

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 1 August 1979

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR COPPER ADHESION.

The material was tested on an Instron Universal Testing Machine Model # TTD. The material meets the requirement of the Test Plan M-24-6-866 Section II-C-1. Quality Assurance Report R 225952 is attached to this certificate of compliance and delineates the data obtained and the method of testing. Calibration on equipment is not due until 21 February 1980.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Test Coupons			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: R. Sawyer Test Engr.
(AUTHORIZED SIGNATURE)

NAME: H. D. Harris

TITLE: Chief QA Inspection
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS
POMONA DIVISION
SI FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hardware

NO. R225952 1

1) Cat	2) Report Facility	3) Init Dept	4) Contract Cd	5) Level	6) Cst Ctr	7) TDR Code	8) Emp No	9)	10) Task No or EWO
	PD	24-6					12378		

11) Ref Orig QAR	12) T.E. No & Dash No	13) TFCAR Cd	BA	15) Item Name
			A	Valox/Copper Test Coupon

16) Item Part No	17) Serial No	Cont? Page A	18) Test Type	19) New Work?	20) Supplier Name
		Y		Y N	

23) Test Procedure Method	24) Shop Order Dc No	25) Foreman (Print)	26) Date Initiated Day Mo Yr	27) Time
Mil-Std-P-55617	/		17 07 79	

28) MRB Reqd?	29) No Insp	30) No Rej	31) Lot Qty	Sample Qty Rej	32) Govt Furn?	33) Task No	34) Priority
Y					Y		

21) Discrepancy or Requirement

#1

Test per Test Plan M-24-6-866
Section II-C-I
Contract N66001-79-C-0022 WJC

Suppl Used? Y
Spl Rostd? Y

67) Resp Dept	74) C/A Status	75) NC AR	72) C/A Assigned to	81) CAJ 1	77) D C 1	22) Control Grp	46) SHOP	47) INSP	48) CUST
	NACK		–						

45) Fix or Disposition

HA

Y Y Y Y

ABC Y N Y N

CLIP OUT

A
B
C
D
E

C-2

080878

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hard-ware

NO. R225952

B

LB 70) Failure Diagnosis/Analysis

Peel Strength
Electroless Copper / Valox 420-SEO
(Mil-Std-P-55617)

Sample	Strength
53	3.6 lb/in width
54	2.6 "
55	2.6 "

8-1-79

M/FB

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

78) CORRECTIVE ACTION

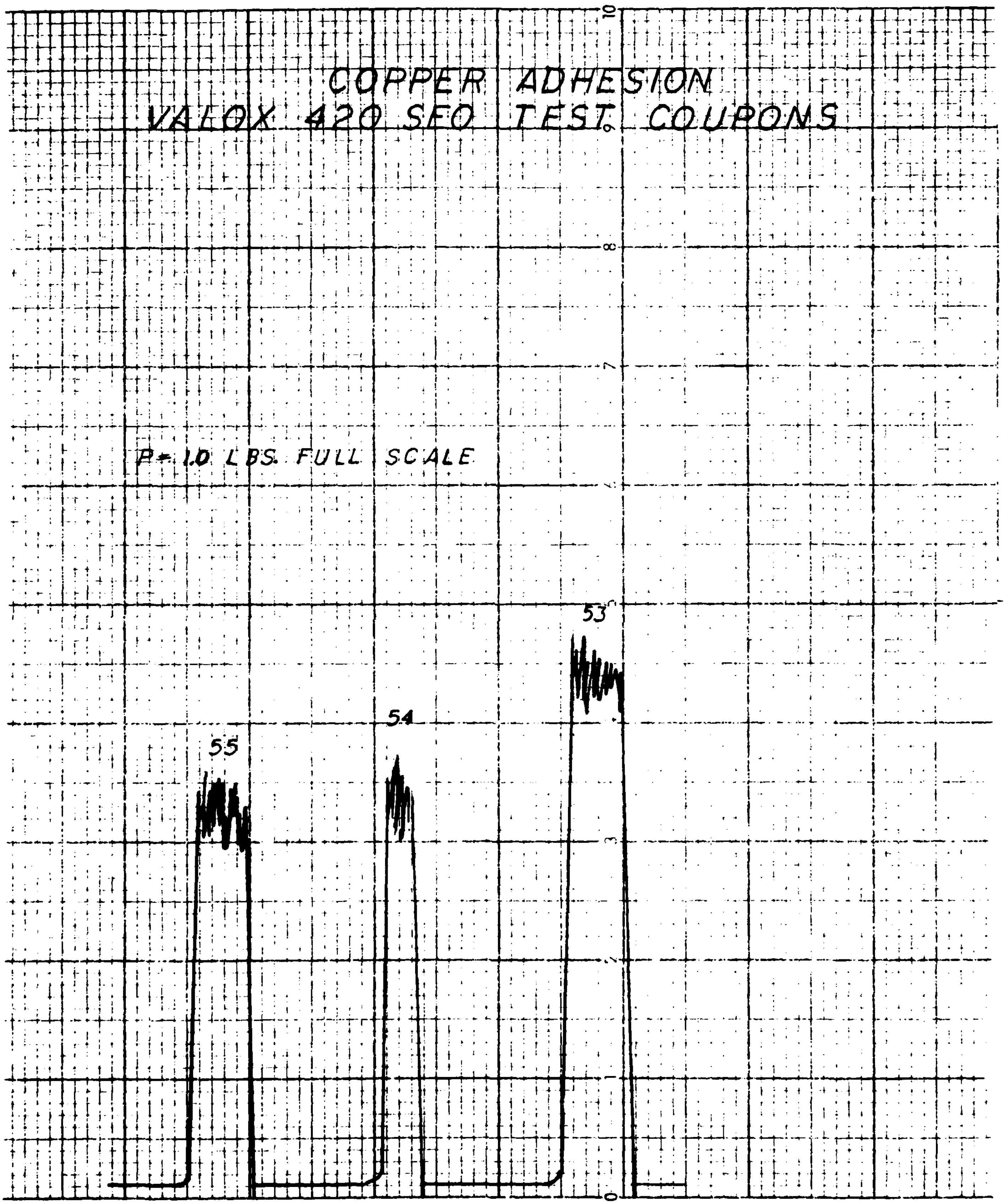
Supp. used? Y

71) Reference Cap. No	72) C/A Assigned to	74) C/A Status	75) NC	76) CA?	85) Classify as Problem No
	—			Y	

CHANGE OR UPDATE THE FOLLOWING DATA BLOCKS AS INDICATED

CAU 1	CAU 2	CAU 3	CAU 4	87 Resp. Dept	Supplier Name	Supplier ID No	MRB
					C-3		Y

B C


COPPER ADHESION
VALOX 420 SEO TEST COUPONS
P = 10 LBS. FULL SCALE
55
54
53
10
8
7
0

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 29 August 1979

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR COPPER THICKNESS AND UNIFORMITY.

The material was inspected on a Balphot Metallograph Cat. #42-31-22. The material meets the requirements of the Test Plan M-24-6-866 Sections II-C-2 and II-C-3. Quality Assurance Report R225978 is attached to this certificate of compliance and delineates the data obtained.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Test Coupons			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: [signature]
(AUTHORIZED SIGNATURE) Test Engr.

NAME: H. J. Harre

TITLE: Chief of Inspection
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hardware

NO. R225978 1

Field	Entry
1) Cat	
2) Report Facility	PD
3) Init Dept	24-6
4) Contract Cd	
5) Level	
6) Cst Ctr	
7) TDR Code	
8) Emp No	12378
10) Task No or AWO	327 M
11) Ref Orig QAR	
12) T.E. No. & Dash No	
13) TFCAR Cd	
BA	A
15) Item Name	
16) Item Part No	
17) Serial No	
Cont? Page A	Y
18) Test Type	
19) New Work?	Y N
20) Supplier Name	
23) Test Procedure Method	
24) Shop Order/Or No	
25) Foreman (Print)	
26) Date Initiated (Day Mo Yr)	26 07 79
27) Time	
28) MRB Reqd?	Y
29) No Insp.	
30) No Rej	
31) Lot Qty	
Sample Qty Rej	
32) Govt Furn?	Y
33) Task No	
34) Priority	

21) Discrepancy or Requirement

#1

Test per Test Plan M-24-6-866
Sections II-C-2, II-C-3
Contract N66001-79-C-0022 WJC

Suppl Used? Y
Spl Rcstd? Y

87) Resp Dept	74) C/A Status	75) NC AR	72) C A Assigned to	81) CAU-1	77) D C-1	22) Control Grp
	NACK		–			

FD STAMPS: 46) SHOP 47) INSP 48) CUST

45) Fix or Disposition

Idfy Parts with QAR No? Y Disp/Plan Suppl? Y QAR Split? Y TRR Supl? Y

96) Rec Rpt No 97) Purch Order No 98) Group 99) Supplier ID No

35) Other Dispos. 36) No Rwk 37) No Rpr 38) No Scrap 39) No Rtn 40) Std Fpr ABC 41) Y N 42) AS Conform? Y N 43) $ Cost 44) Exp Of

100) Disp Qual Rep 101) Engr Rep 102) 103) Cust Rep 104) Buyer Rep 105) Disp Date Day Mo Yr

CLIP OUT DETAILS F... VED-REPLACED SCRAPPED

STEP	60) DEFECT DTL NAME	61) CIR LOC	62) PART NO	63) QTY	64) CT	65) SDF	66) SUPP OR MFGR NAME	67) RESP DATE CODE	68) DEFECT CD
KA									
KB									
KC									
KD									
KE									
KF									

Hours Tenths · Reviewed By · TFCAR Close Date · Day Mo Yr · SC · 514 No QAR

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hard-ware

NO. R225978

B

70) Failure Diagnosis / Analysis

Copper Thickness
Electroless Copper / Valox 420-SEO

Coupon #		Position	Thickness $\cdot 10^{-3}$
59	mt #3181	Top	.77
59		Middle	.75
59		Bottom	.76
60	mt #3181	Top	.93
60		Middle	.90
60		Bottom	.89
61	mt #3182	Top	.91
61		Middle	.96
61		Bottom	.94

M/FB

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

18) CORRECTIVE ACTION

Coupon #		Position	Thickness
62	mt #3182	Top	.97
62		Middle	.96
62		Bottom	.96
63	mt #3183	Top	.93
63		Middle	.95
63		Bottom	.94
64	mt #3183	Top	.97
64		Middle	.95
64		Bottom	.97

8-28-79

Y

71) Reference Cap No | 72) C A Assigned to — | 74) C A Status | 75) NC | 76) CA? Y | 85) Classify as Problem No

CHANGE OR UPDATE THE FOLLOWING DATA BLOCKS AS INDICATED

SC | 81 CAU 1 | 82 CAU 2 | 83 CAU 3 | 84 CAU 4 | 87 Resp. Dept | Prod. Supplier | 99 Subject NC | 25 MRB Y

A B C | C-7 | Close Date Day Mo Yr

GD
GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 3 JANUARY 1980

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR SURFACE FINISH.

The material was inspected on a Taylor Hobson Talysurf 10. The surface finish of the six electroless copper/Valox 420-SEO test coupons was less than $\sqrt{100}$.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Test Coupons			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: F. C. Breslin
(AUTHORIZED SIGNATURE)

NAME: H. J. Havel

TITLE: Chief Of Inspection
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

APPENDIX D

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX D

THERMAL SHOCK - PLATING INTEGRITY OF COUPONS

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 17 September 1979

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR PLATING INTEGRITY AFTER THERMAL SHOCK.

The material was visually inspected for delamination and blistering of copper on the test coupons. The material meets the requirement of the Test Plan M-24-6-866 Section II-D-1. Quality Assurance Report R272259 is attached to this certificate of compliance.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Test Coupons			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: (AUTHORIZED SIGNATURE) Test Engr.

NAME: H. J. Hansel

TITLE: Chief Of Inspection
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

0) CIRCLE REPORT TYPE: A B D (Hardware) — D circled

NO. R272259 1

AA
1) Code: 1
2) Report Facility: PD
3) Init Dept: 24-6
4) Contract Cd:
5) Level:
6) Cst Ctr:
7) TDR Code:
8) Emp No: 12378
10) Task No. or AWO: 327M
11) Ref. Orig. QAR:
12) T.E. No. & Dash No:
13) TFCAR Cd:
BA: A
15) Item Name: Valox/Copper Coupons
16) Item Part No.:
17) Serial No:
Cont? Y Page A
18) Test Type:
19) New Work? Y N
20) Supplier Name:

EA
23) Test Procedure, Method:
24) Shop Order/Op No:
25) Foreman (Print):
26) Date Initiated (Day Mo Yr): 09 08 79
27) Time:

FA
28) MRB Reqd? Y
29) No. Insp:
30) No. Rej.:
31) Lot Qty.:
Sample Qty. Rej:
32) Govt. Furn? Y
33) Task No.:
34) Priority:

DA #1
21) Discrepancy or Requirement

Test per Test Plan M-24-6-866
Section II-D-1
Contract N66001-79-C-0022 WJC

Suppl Used? Y
Split Rqstd? Y

SC
87) Resp. Dept.:
74) C/A Status: NACK
75) NC AR:
72) C/A Assigned to: —
81) CAU-1:
77) D.C-1:
22) Control Grp:
FIX STAMPS: 46) SHOP 47) INSP 48) CUST

GA
45) Fix or Disposition (Recommended Disposition)

Idfy Parts with QAR No? Y
Disp. Plan Suppl? Y
QAR Split? Y
TRR Supl? Y

HA
96) Rec. Rpt No.:
97) Purch. Order No:
98) Group:
99) Supplier ID No.:

SC
35) Other Disp(s):
36) No. Rwk.:
37) No. Rpr:
38) No. Scrap:
39) No. Rtn.:
40) Std Rpr? ABC
41) Y N
42) AR Conform? Y N (Y circled)
43) $ Cost:
44) Exp. Of:

QA
100) Disp. Qual. Rep.:
101) Engr. Rep:
102)
103) Cust. Rep:
104) Buyer Rep.:
105) Disp. Date (Day Mo Yr):

CLIP OUT/DETAILS REMOVED-REPLACED/SCRAPPED

59) REF STEP	60) DEFECT DTL NAME	61) CIR LOC	62) PART NO	63) QTY	64) CT?	65) SCRP	66) SUPP OR MFGR NAME	67) RESP DATE CODE	68) DEFECT CD
KA									
KB									
KC									
KD									
KE									
KF									

NA
88) Labor M/H (Hours Tenths):
89) Reviewed by:
90) TFCAR Close Date: D-2
91) Closeout Date (Day Mo Yr): 18 09 79
92) Est $ Cost:
93) Insp: GD 260 P
94)
SC
51) Init QAR:

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hardware

NO. R272259 B

LB 70) Failure Diagnosis/Analysis

Sample	Delamination	Blistering
65	None	None
66	None	None
67	None	None
68	None	None
69	None	None
71	None	None

Khaurye 9-18-79

M/FB

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

UE #1 118. CORRECTIVE ACTION

Supp. used? Y

C | 71) Reference Cap. No. | 72) C A Assigned to — | 74) C A Status | 75) NC | 76) CA? Y | 65) Classify as Problem No

CHANGE OR UPDATE THE FOLLOWING DATA BLOCKS AS INDICATED

SC | 81) CAU 1 | 82) CAU 2 | 83) CAU 3 | 84) CAU 4 | 57) Resp. Dept. | Resp. Supplier Name | 93) Supplier No. | 28) MRB Y

A B C | D-3 | Date: Day Mo Yr

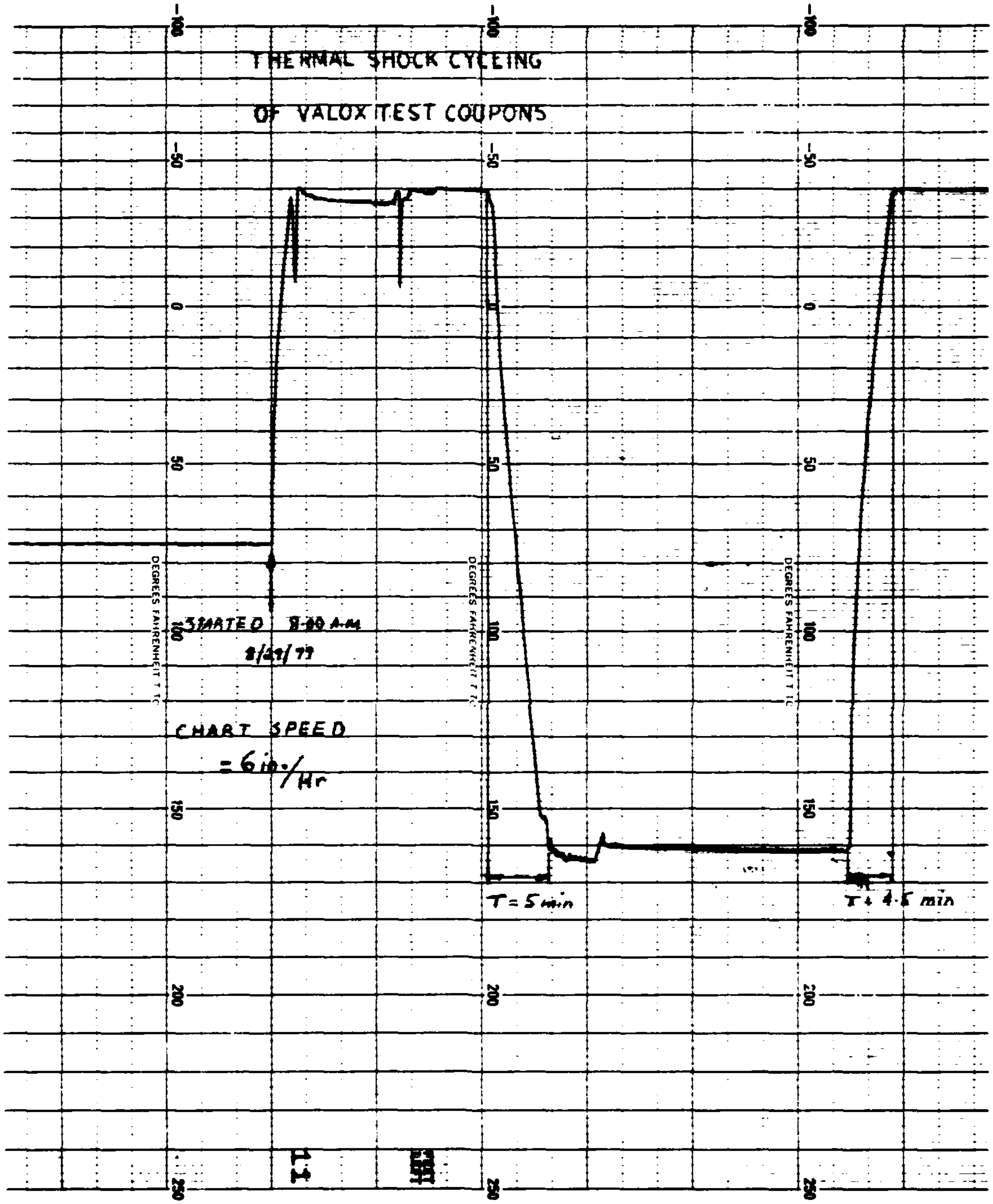


FIGURE D-1
(Sheet 1 of 9)

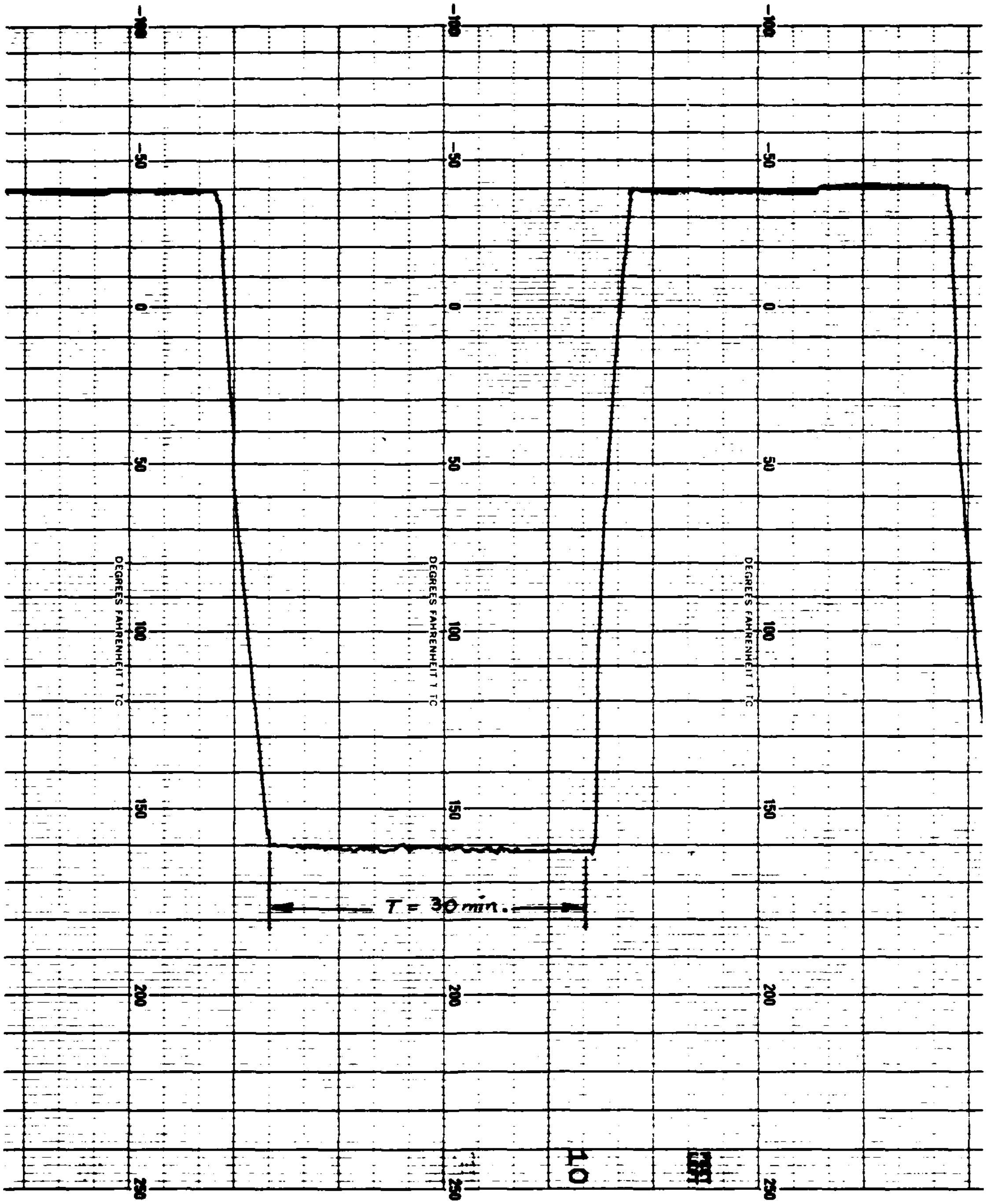


FIGURE D-1
(Sheet 2 of 9)

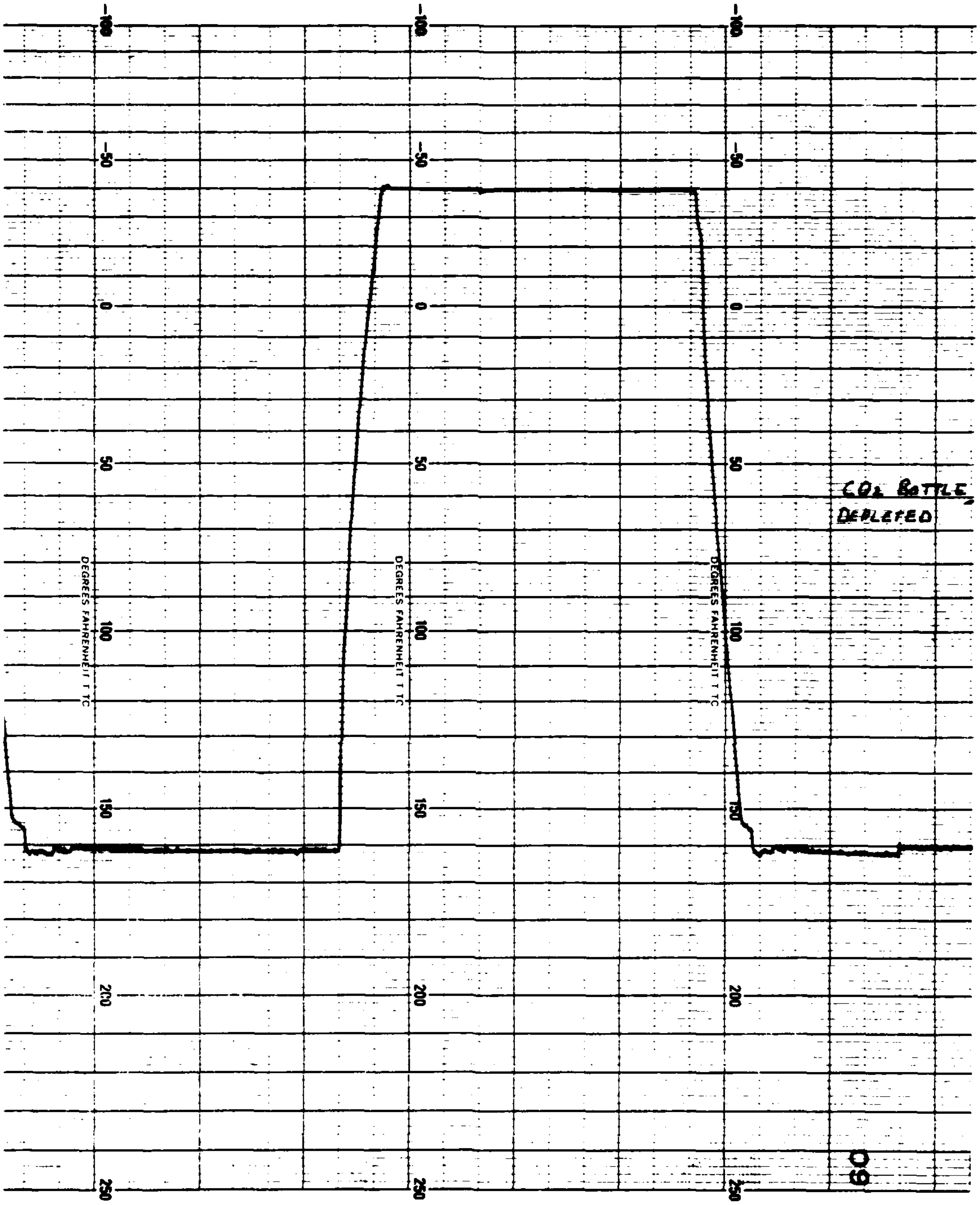


FIGURE D-1
(Sheet 3 of 9)

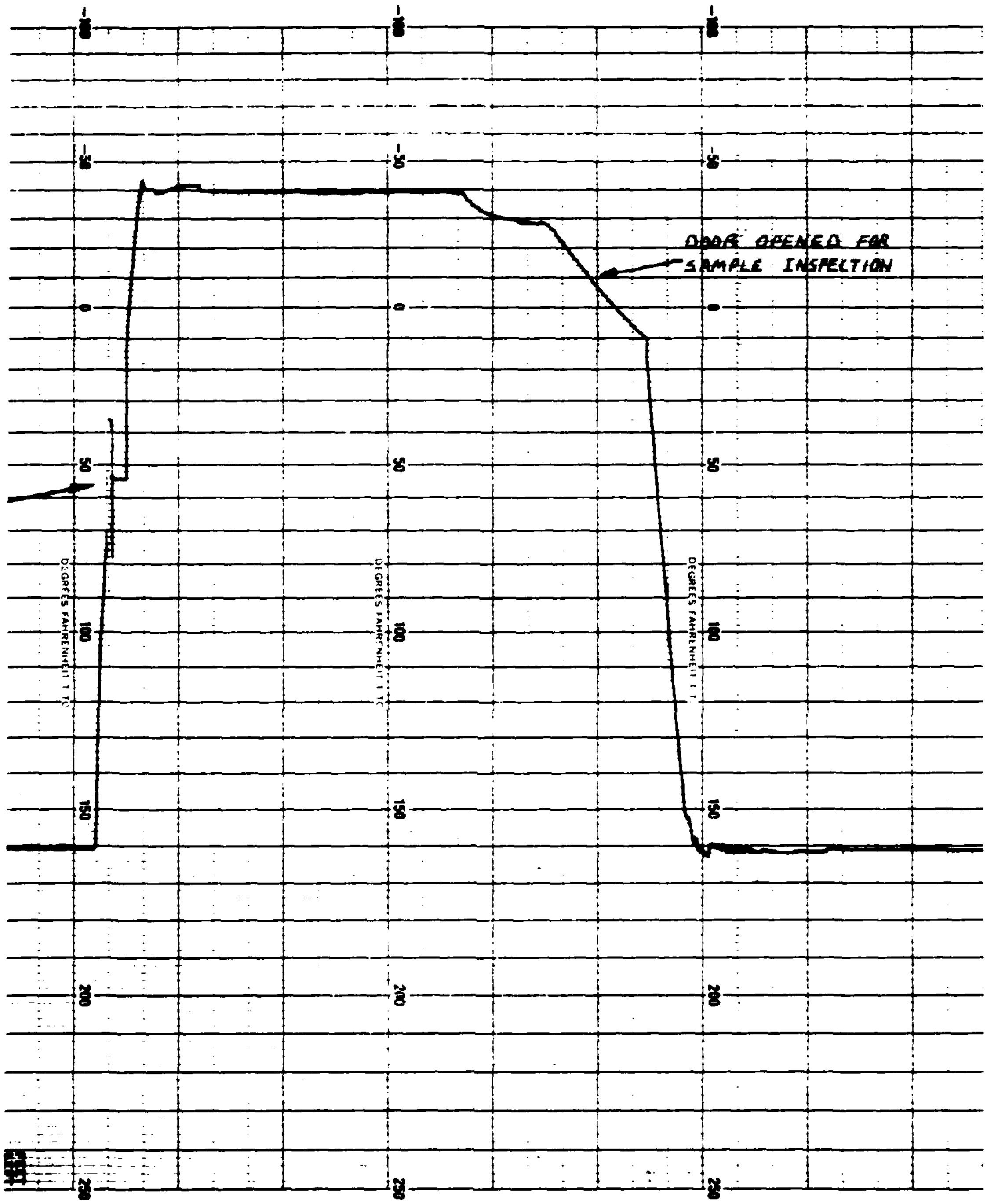


FIGURE D-1
(Sheet 4 of 9)

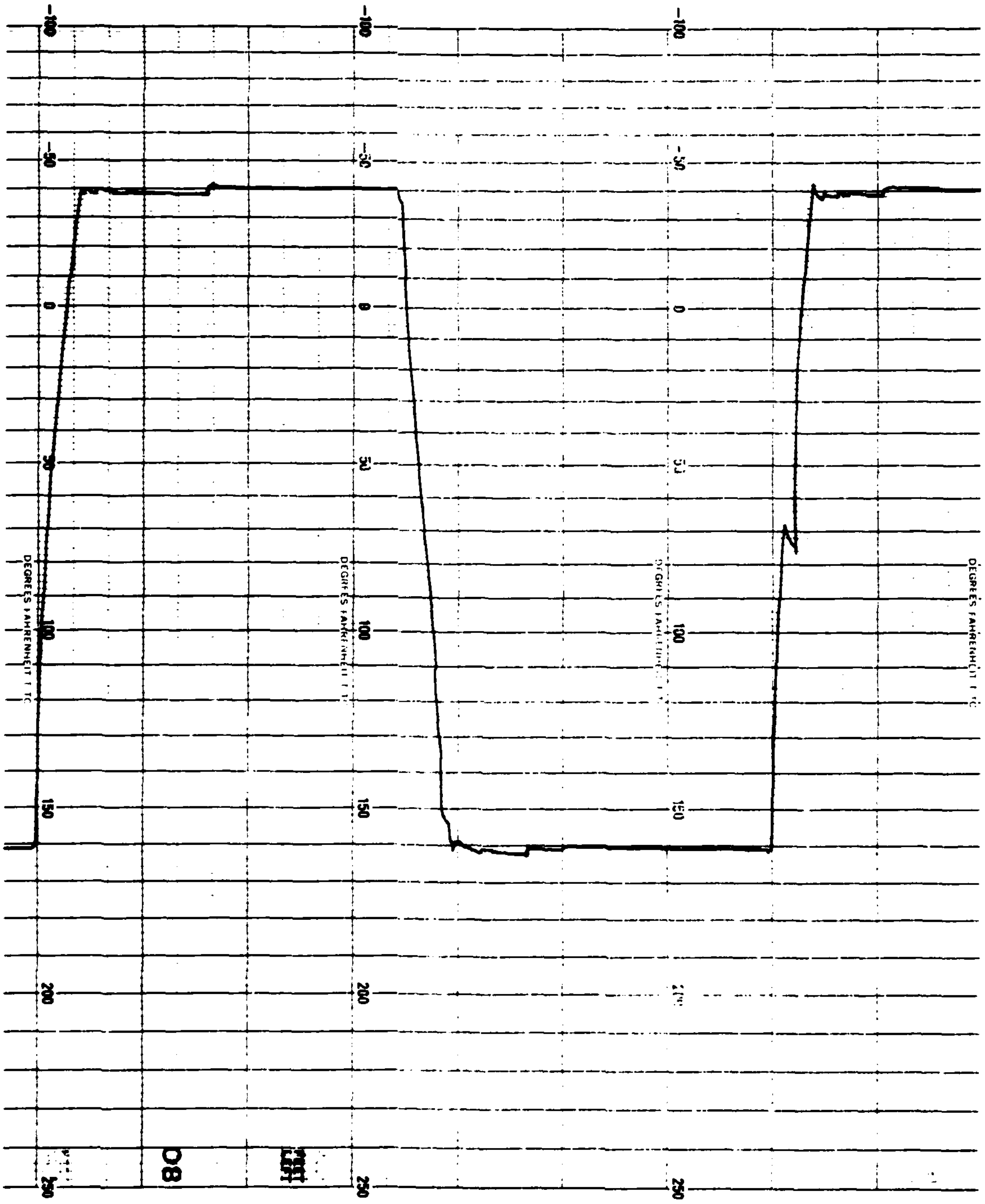


FIGURE D-1
(Sheet 5 of 9)

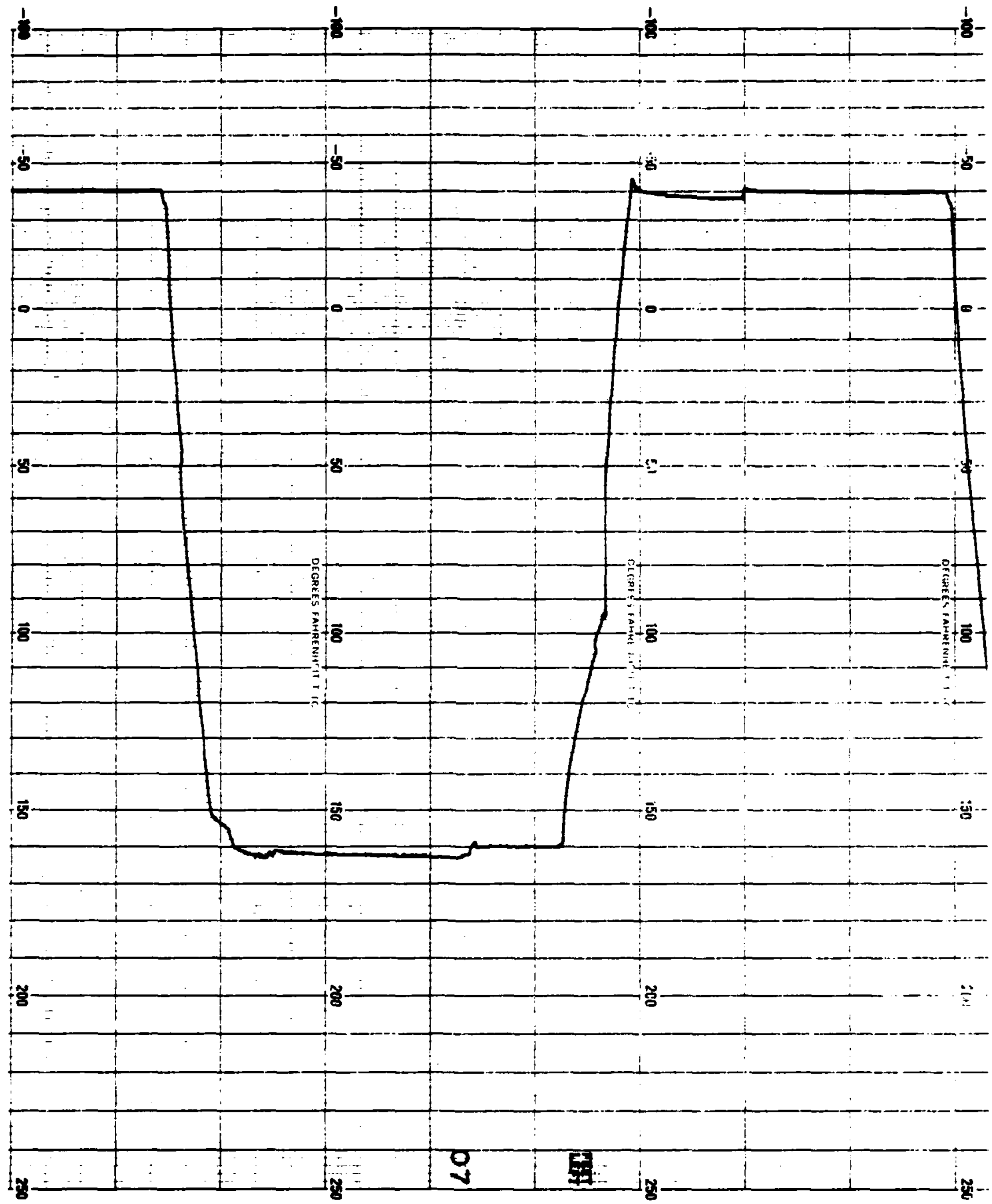


FIGURE D-1
(Sheet 6 of 9)

FIGURE D-1
(Sheet 7 of 9)

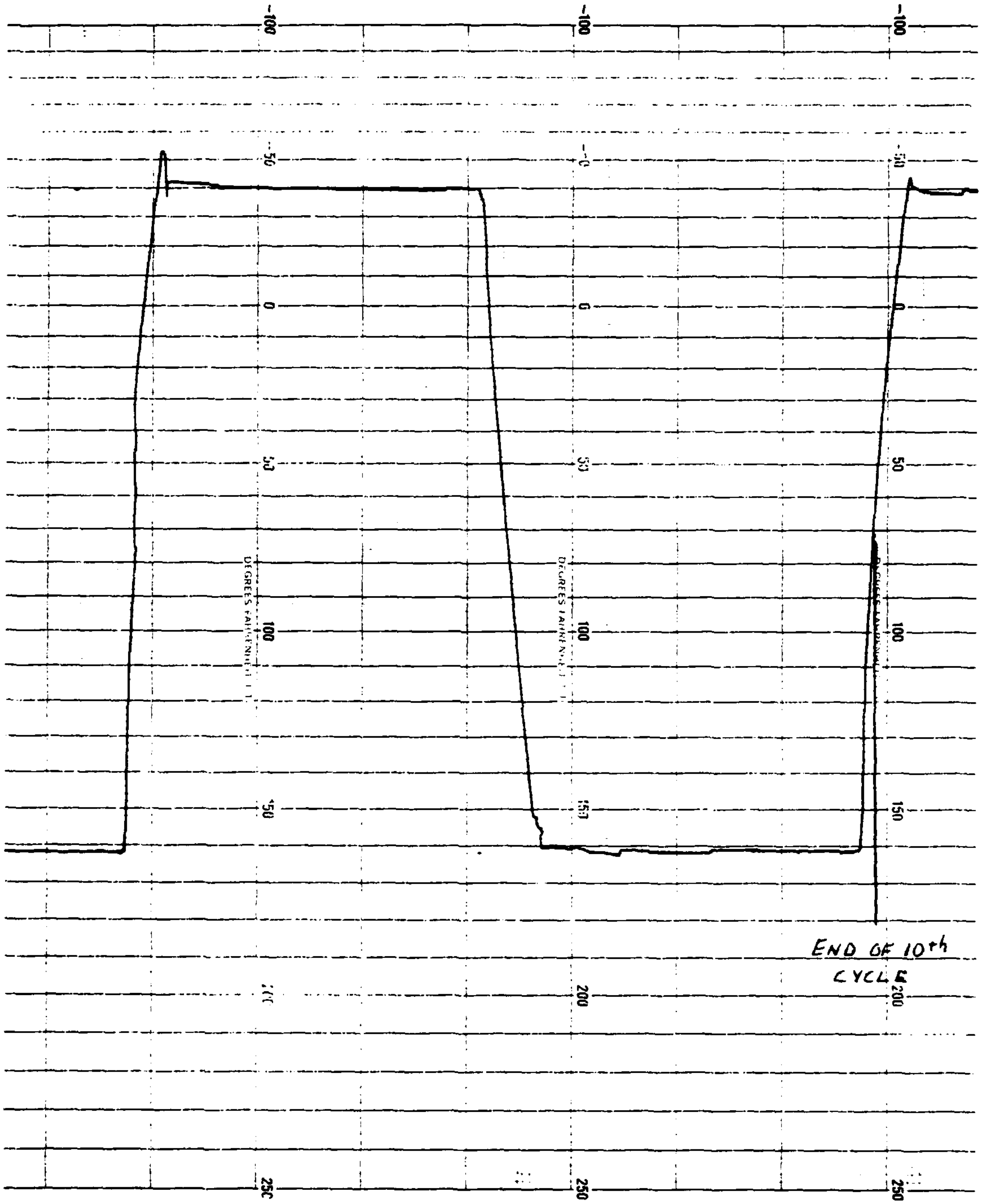


FIGURE D-1
(Sheet 8 of 9)

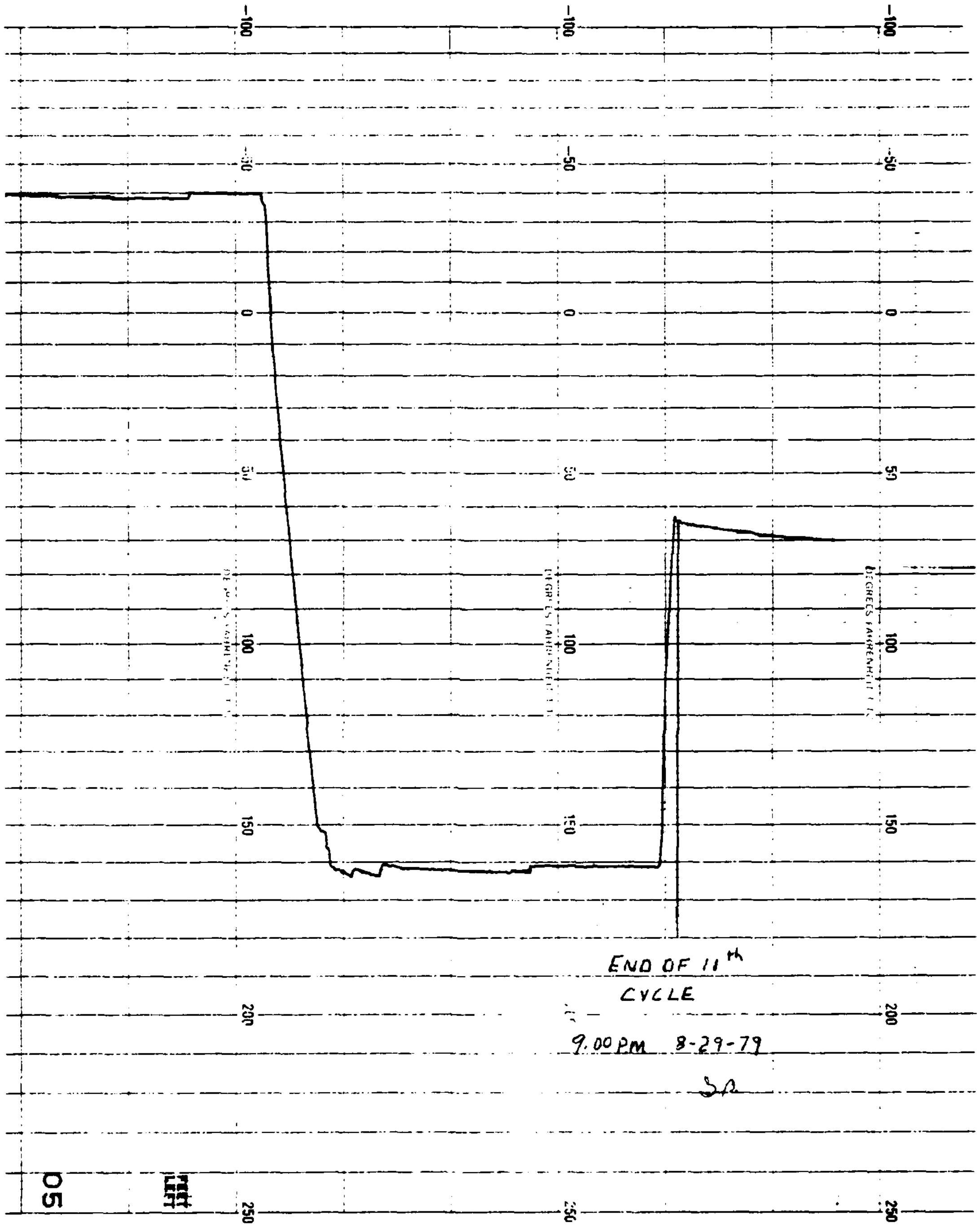


FIGURE D-1
(Sheet 9 of 9)

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX E

APPENDIX E

TOOLING MOLDS - DIMENSIONAL ACCURACY

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 13 November 1979

TO: W. L. MacTurk

It is hereby certified that the mold described herein has been inspected for the following:

Input and output post diameters; Post separation; Post Length; Waveguide depth; Waveguide length; and Waveguide width. The mold met the dimensions given by Tool Drawing 24-6-101 with the tolerances taken from the Naval Test Plan Section II-F.

DESCRIPTION			
S13 Filter, Waveguide Cavity Mold, 24-6-101			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
5188425		196911	
OTHER DOCUMENTATION			
N66001-79C-0022 WJC			

BY: (AUTHORIZED SIGNATURE)

NAME: A. L. Lloyd

TITLE: SR. TOOL ENGR.

QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 14 November 1979

TO: W. L. MacTurk

It is here by certified that the mold described herein has been inspected for the following: input and ouput connector hole diameters and spacings; post diameters; post spacings; and post lengths. The mold met the dimensions given by the Tool Drawing 24-6-100 with the tolerances taken from the Naval Test Plan Section II-F.

DESCRIPTION			
S13 FILTER, CAP MOLD, 24-6-100			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
5188424		196907	
OTHER DOCUMENTATION			
N66001-79C-0022 WJC			

BY: L. Wheeler
(AUTHORIZED SIGNATURE)

NAME: A. L. Lloyd

TITLE: SR Tool Engr.
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 15 January 1980

TO: W. L. MacTurk

It is hereby certified that the drill fixture described within has been inspected for the following: tuning screw hole spacings, alignment pin spacings, waveguide insert width, and waveguide insert depth. The drill fixture met the dimensions given by the Tool Drawing 24-6-102 with the tolerances taken from the Naval Test Plan Section II-F-5.

DESCRIPTION			
S13 FILTER, TUNING SCREW DRILL FIXTURE 24-6-102			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
5188425			
OTHER DOCUMENTATION			
N66001-79C-0022 WJC			

BY: (AUTHORIZED SIGNATURE)

NAME: G. L. Lloyd

TITLE: CHIEF - FABRICATION INSPECTION
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX F

APPENDIX F

DIMENSIONAL TOLERANCE ACCURACY OF INJECTION MOLDED FILTER

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 27 March 1980

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT FIVE S13 FILTERS HAVE BEEN INSPECTED AND MET THE FOLLOWING TOLERANCES WITH THE DIMENSIONS TAKEN FROM THE ENGINEERING DRAWINGS SPECIFIED BELOW.

1. Post diameters perpendicular to center of B Plane $\pm$ .001".
2. Post separations $\pm$ .003".
3. Post Length $\pm$ .002".
4. Post perpendicularities $\pm$ .003".
5. Average concentricity of tuning posts to tuning screws in longitudinal Plane $\pm$ .004".
6. Waveguide length, width, and depth $\pm$ .005".

DESCRIPTION			
S13 FILTER ASSEMBLY			
PART NUMBER	**REVISION**	**PURCHASE ORDER NUMBER**	**PACKING SHEET NUMBER**
5188423	-	-	-
OTHER DOCUMENTATION			
Engr. Drawings #5188423 5188424, 5188425, 5188409, 5188415			

BY: ______________
(AUTHORIZED SIGNATURE)

NAME: ______________

TITLE: CHIEF FAB. INSP.

QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX G

APPENDIX G

COPPER AND GOLD PLATING OF FILTERS - DIMENSIONAL ACCURACY

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 29 January 1980

TO: W. L. MacTurk 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR COPPER THICKNESS AND UNIFORMITY.

The material was inspected on a Balphot Metallograph Cat. #42-31-22. The material meets the requirements of the Test Plan M-24-6-866 Section II-G-1. Quality Assurance Report R394859 delineates the data obtained for the five waveguide filters.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Filters			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
5188423			
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: TEST ENGR.
(AUTHORIZED SIGNATURE)

NAME:

TITLE: Chief Of Inspection

QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-172

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D — NO. R394859 — 1

Field	Entry
2) Report Facsn	PD
3) Init. Dept	24-6
8) Emp. No.	12378
10) Task No.	327M
14) BA	A
Cont?	Y
19) New Work?	Y N
26) Date Initiated	011028 0
28) MRB Reqd?	Y
32) Govt. Furn?	Y

21) Discrepancy or Requirement

#1 Test per Test Plan M-24-6-866
Section II-G-1
Contract N66001-79-C-0022 WJC

Supp Used? Y
Soft Found? Y

Field	Entry
74) C/A Status	NACK
72) C/A Assigned to	–

45) Fix or Disposition

Idfy Part w/ QAR No? Y — Disp Per Supp? Y — QAR Soft? Y — TRP Supp? Y

40) Std Rpt: ABC — Y N — 42) AF Conform? Y N

CLIP OUT/DETAILS REMOVED-REPLACED-SCRAPPED

59) REF STEP	60) DEFECT DTL NAME	61) CIF LOC	62) PART NO	63) QTY	64) CTY	65) SCP	66) SUPP OR MFGR NAME	67) RESP DATE CODE	68) DEFECT CD
KA									
KB									
KC									
KD									
KE									
KF									

88) Labor M — 89) Reviewed by — 90) TFCAR Close Date — G-2 — Closeout Date

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-537 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hardware

NO. R394859 B

Copper Thickness
Electroless Copper / Valox 420-SEO Filters

Body	Thickness $\cdot 10^{-3}$	Mount #
1	0.8	3385
2	0.9	3356
3	0.8	3356
4	0.7	3356
5	0.8	3385

M/FB

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

118 CORRECTIVE ACTION

Cap	Thickness 10^{-3}	Mount #
1	0.8	3357
2	0.7	3357
3	0.8	3357
4	0.8	3385
5	0.8	3385

2-29-80
G Nash

Supp. used? Y

71 Reference Doc. No.	72 C A Assigned to	74 C A Status	75 NC	76 CA?	85 Classify as Problem No.
–	—			Y	

CHANGE OR UPDATE THE FOLLOWING DATA BLOCKS AS INDICATED

SC	CAU-1	82 CAU-2	83 CAU-3	84 CAU-4	87 Resp. Dept.	20 Resp. Supplier Name	99 Supplier ID No.	28 MPE
								Y

A B C

72 Action Taken By (Print Last Name) –

GD
GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 5 January 1980

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR SURFACE FINISH.

The material was inspected on a Taylor Hobson Talysurf 10. The surface finish of the five electroless copper/Valox 420-SEO Filters was less than $\sqrt{100}$.

DESCRIPTION			
Electroless Copper/Valox 420/SEO Filters			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: [illegible]
(AUTHORIZED SIGNATURE)

NAME: [illegible] GD 260 P

TITLE: Chief QC Inspector
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-172

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX H

APPENDIX H

THERMAL SHOCK—PLATED INJECTION MOLDED FILTERS

GENERAL DYNAMICS
Pomona Division

TM	24-6-866
MODEL	S13 FILTER
CONTRACT	N66001-79-C-0022

TECHNICAL MEMORANDUM

DATE: 10 January 1980

TO: Mr. John Markall N.O.S.C. San Diego, CA

FROM: Advanced Manufacturing Technology 24-6

SUBJECT:

Thermal Shock - Plated Injection Molded Filter

REFERENCE:

DISTRIBUTION:

LIBRARY

PREPARED BY: C R Auletti
C. R. Auletti

PREPARED BY:

REVIEWED BY: W L MacTurk
W. L. MacTurk

APPROVED BY:
M. L. Charters

(O) FORM 6-660 R1

TABLE H-1

THERMAL SHOCK CYCLING - WATER IMMERSION

FILTER	LONGITUDINAL CRACKING	DELAMINATION	BLISTERING
3	None	None	None
4	None	None	None
5	None	None	None

GENERAL DYNAMICS | POMONA

CERTIFICATE OF COMPLIANCE

DATE: 15 February 1980

TO: W. L. MacTurk Dept. 24-6

IT IS HEREBY CERTIFIED THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN INSPECTED FOR PLATING INTEGRITY AFTER THERMAL SHOCK.

The material was visually inspected for delamination and blistering of copper on the plated valox filters. The material meets the requirement of the Test Plan M-24-6-866 Section I-2-a. Quality Assurance Report R394606 is attached to this certificate of compliance.

DESCRIPTION			
Electroless Copper/Valox 420-SEO Filters			
PART NUMBER	REVISION	PURCHASE ORDER NUMBER	PACKING SHEET NUMBER
-	-	-	-
OTHER DOCUMENTATION			
Contract N66001-79-C-0022 WJC			

BY: [signature] Test Engr
(AUTHORIZED SIGNATURE)

NAME: H. J. Hanel

TITLE: Chief Of Inspection
QUALITY CONTROL DEPARTMENT
GENERAL DYNAMICS/POMONA

FORM 27-372

GENERAL DYNAMICS
POMONA DIVISION
FORM 27-037 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B (D) Hardware

NO. R394606 — 1

Field	Entry
2) Report Form	PD
3) Ind. Dept	24-6
8) Emp. No.	12578
10) Task No. or AWD	327111
15) Item Name	Valox/Copper Filters
Cont?	Y
19) New Work?	Y N
26) Date Initiated	02 01 80
28) MRB Reqd?	Y
32) Govt. Furn?	Y

31) Discrepancy or Requirement

Test per Test Plan M-24-6-866
Section I-2-a
Contract N66001-79-C-0022 WJC

Suppl Used? Y
Split Rcstd? Y

73) Resp. Dept	74) C/A Status	75) NC AR	72) C/A Assigned to	81) CAU 1	77) D. Crit	22) Contrl. Grp
	NACK		–			

FIX STAMPS: 46) SHOP | 47) INSP. | 48) CUST.

45) Fix or Disposition

Y	Disp. First Suppl?	Y	CAR Sold?	Y	TBR Supp?	Y	

95) Rec. Rpt No. | 97) Purch. Order No. | 98) Group | 99) Supplier ID No.

40) Std. Form	41)	42) Conform?	43) $ Cost	44) Exp. Of
ABC	Y N	(Y) N		

100) Disp. Qual. Rep. | 101) Engr. Rep. | 102) | 103) Cust. Rep. | 104) | 105) Disp. Date Day Mo Yr

CLIP OUT/DETAILS REMOVED/REPLACED/SCRAPPED

REF	62) DEFECT NAME	61) LOC	62) PART NO.	63) QTY	64)	65)	66) SUPPLIER/VENDOR NAME	67) PROD. DATE CODE	68) DEFECT CD

030480

GENERAL DYNAMICS
POMONA DIVISION
(S) FORM 27-637 R1

QUALITY ASSURANCE REPORT

CIRCLE REPORT TYPE: A B D Hard-ware

NO. R394606 B

(70) Failure Diagnosis/Analysis

Filter	Delamination	Blistering
3	None	None
4	None	None
5	None	None

3-20-80

M/F8

* * REMOVE FROM MANIFOLD BEFORE FURTHER RECORDING * *

Y

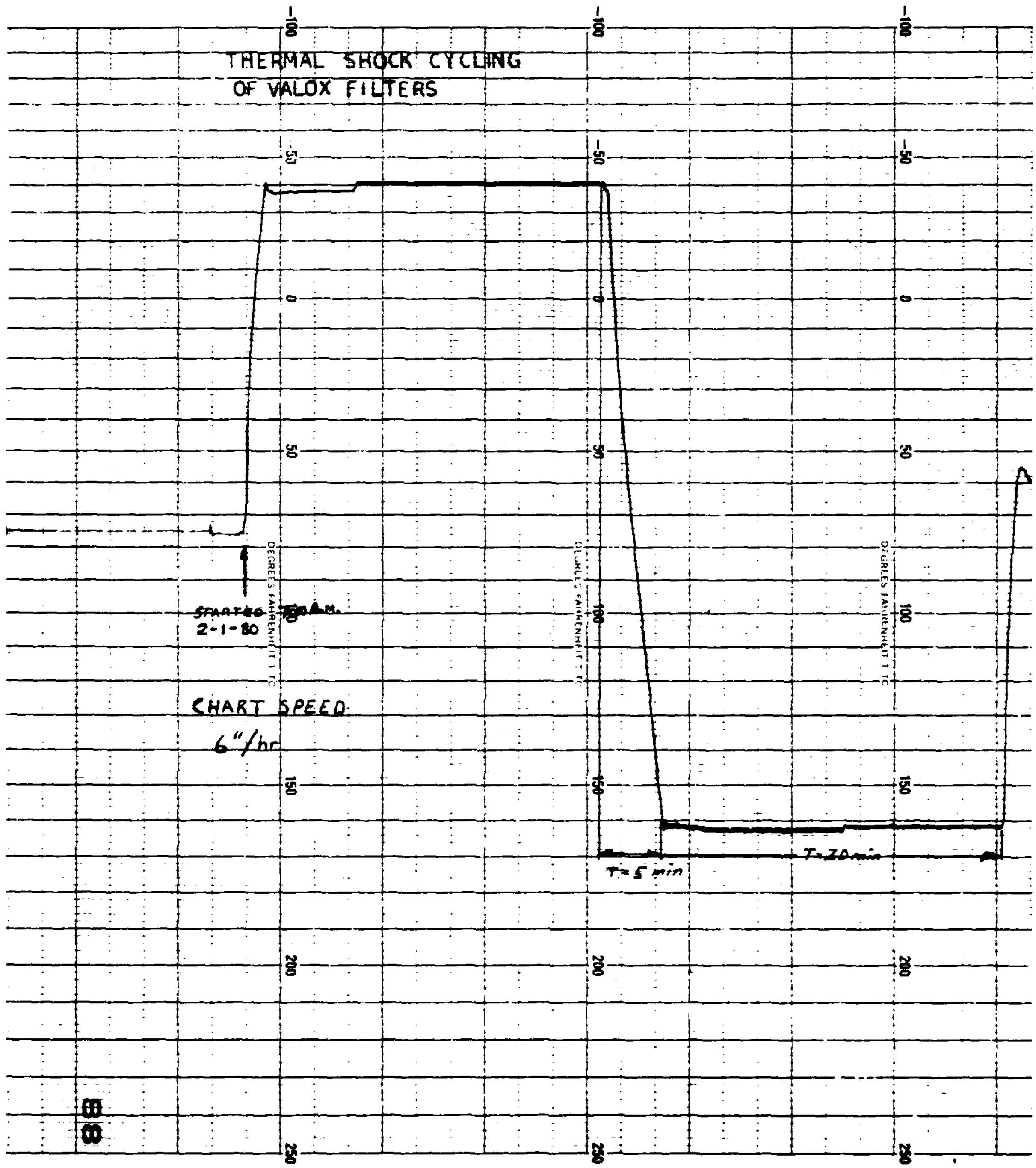


FIGURE H-1
(Sheet 1 of 10)

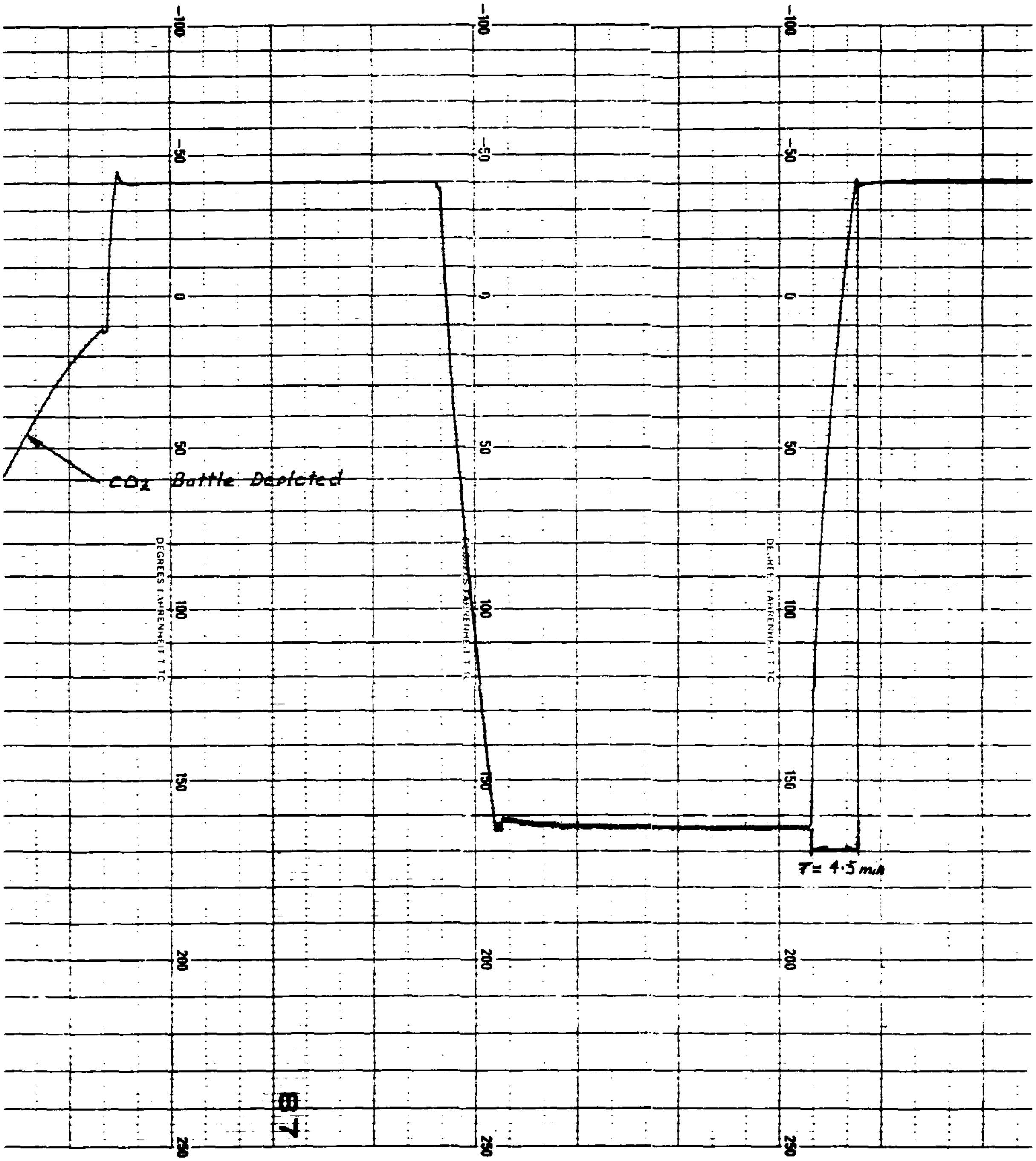


FIGURE H-1
(Sheet 2 of 10)

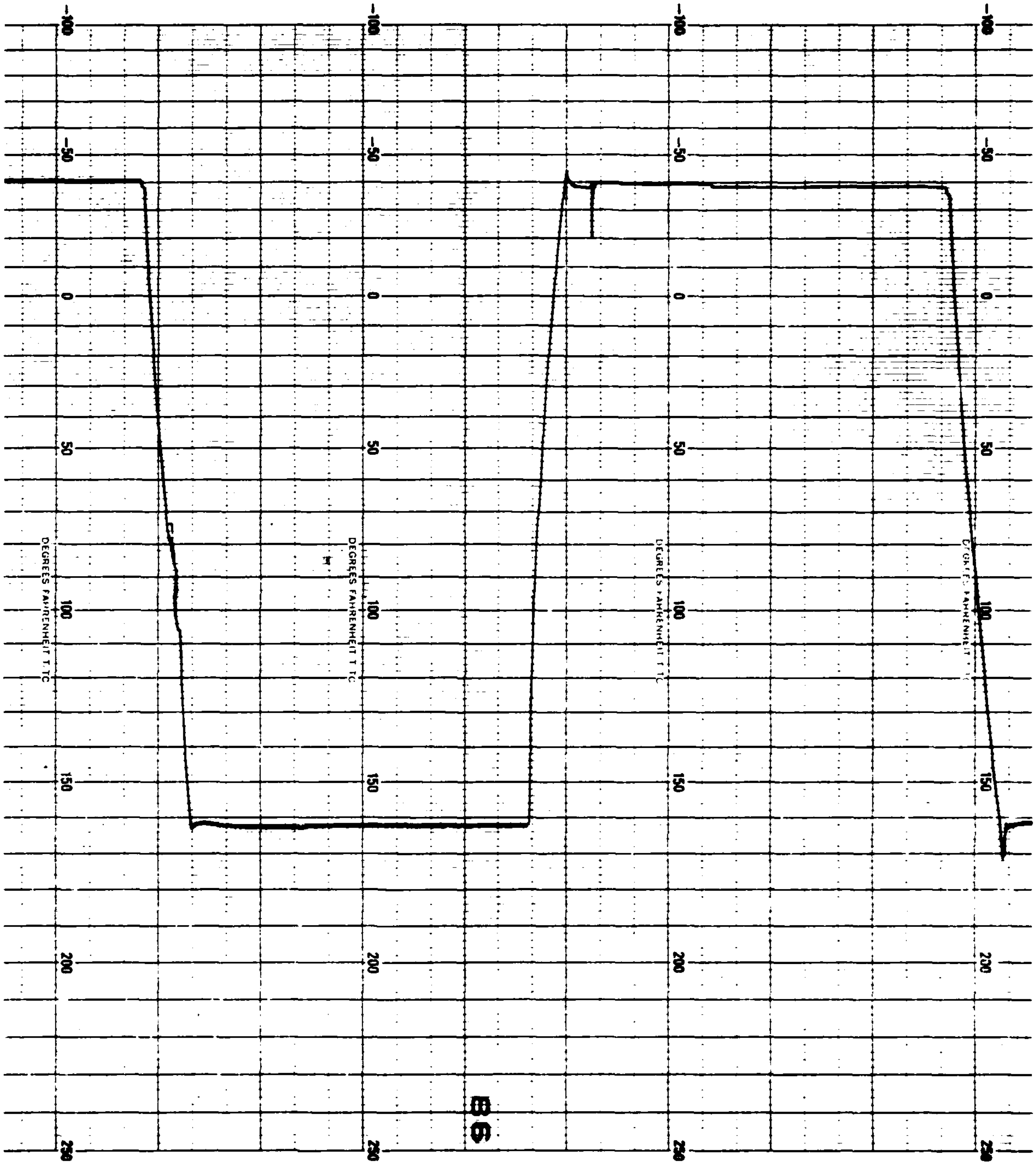


FIGURE H-1
(Sheet 3 of 10)

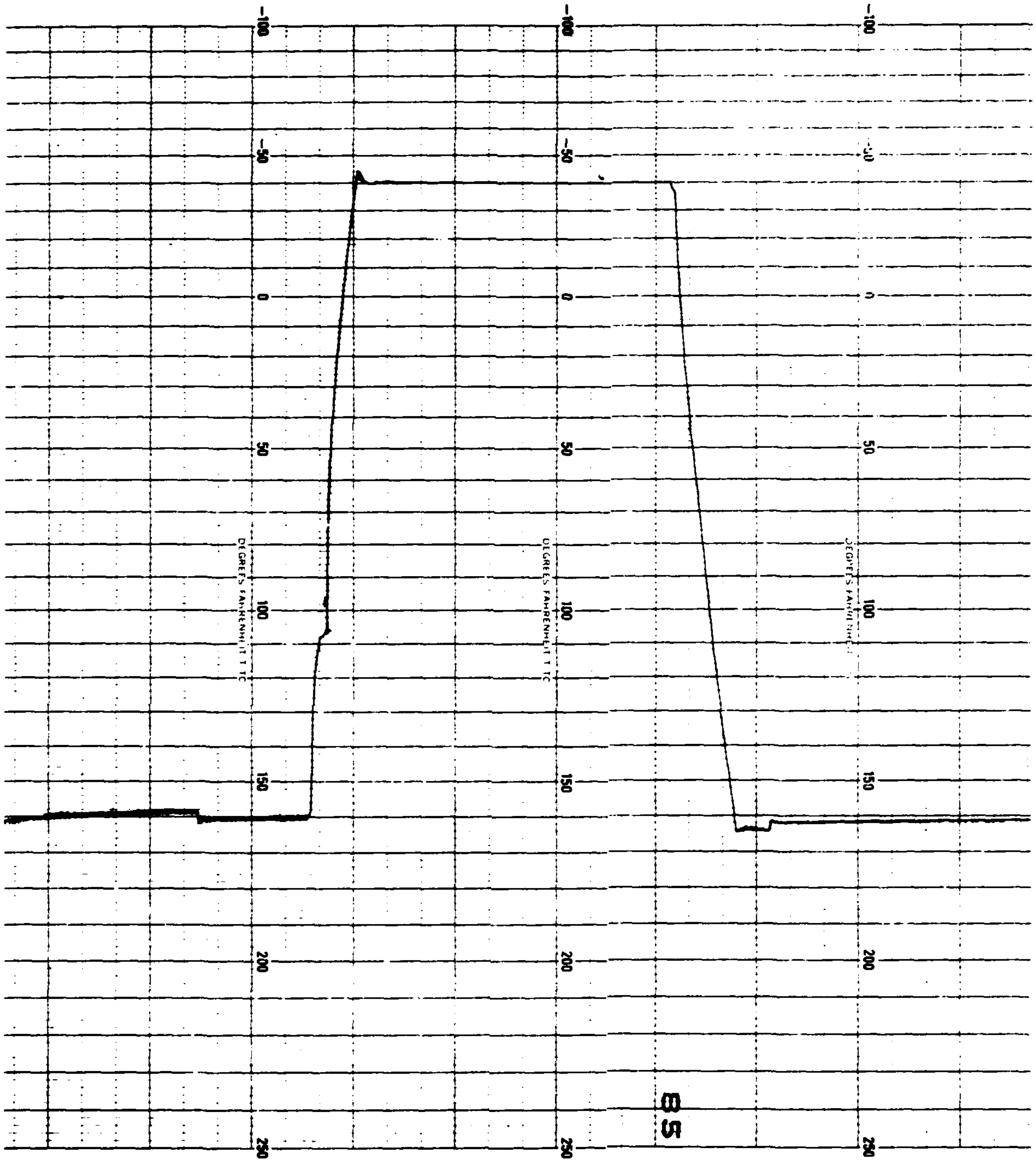


FIGURE H-1
(Sheet 4 of 10)

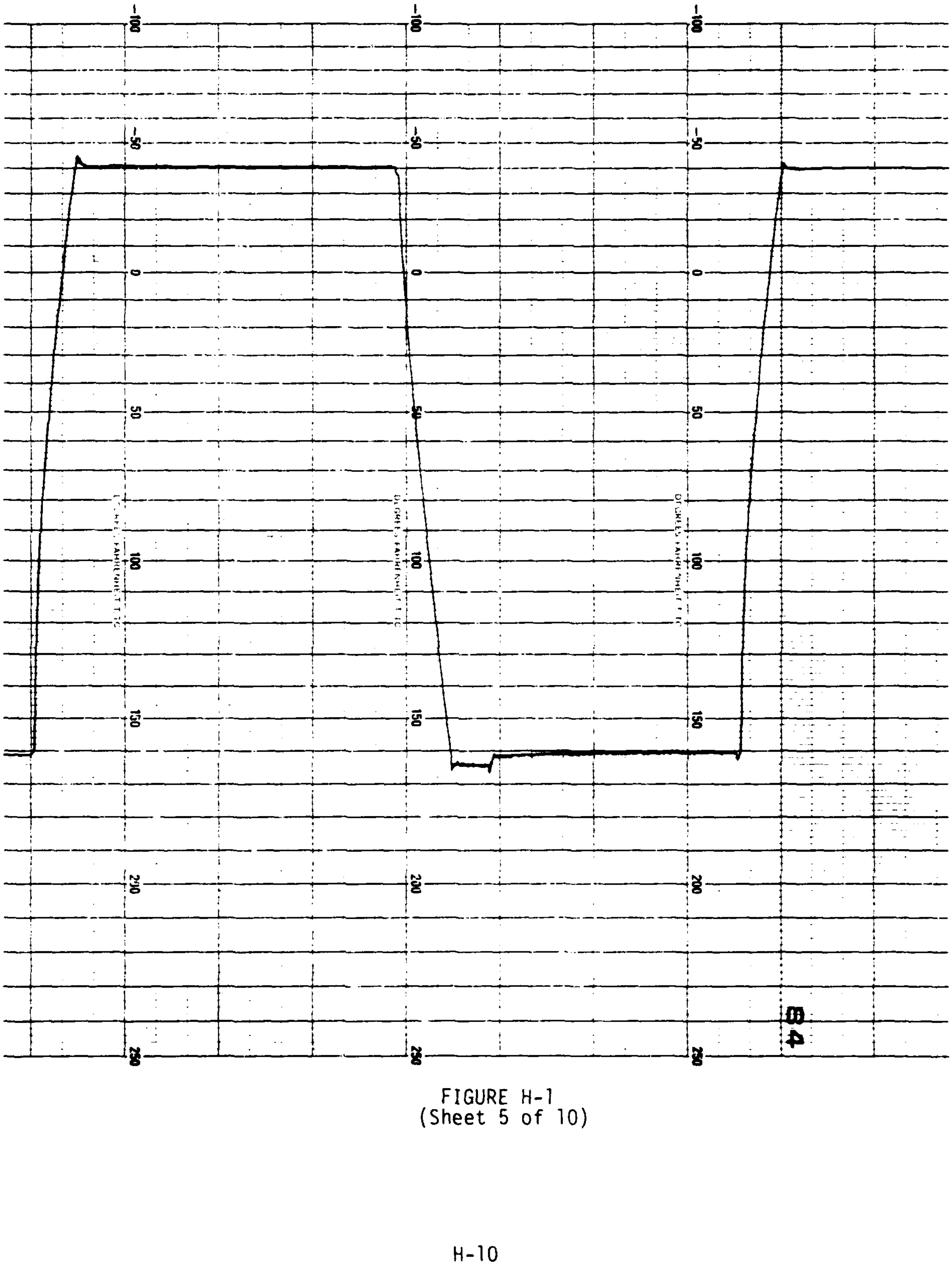


FIGURE H-1
(Sheet 5 of 10)

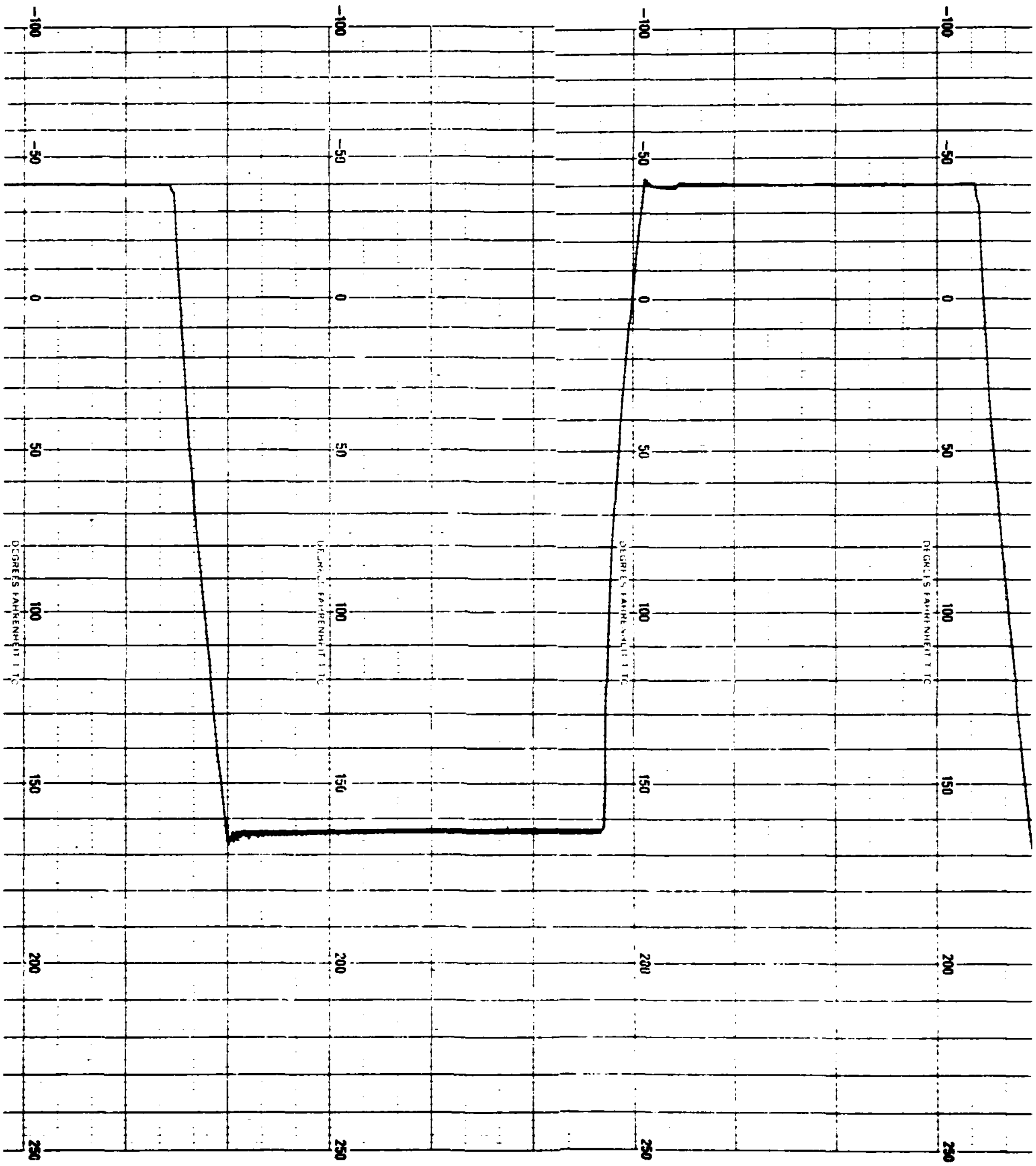


FIGURE H-1
(Sheet 6 of 10)

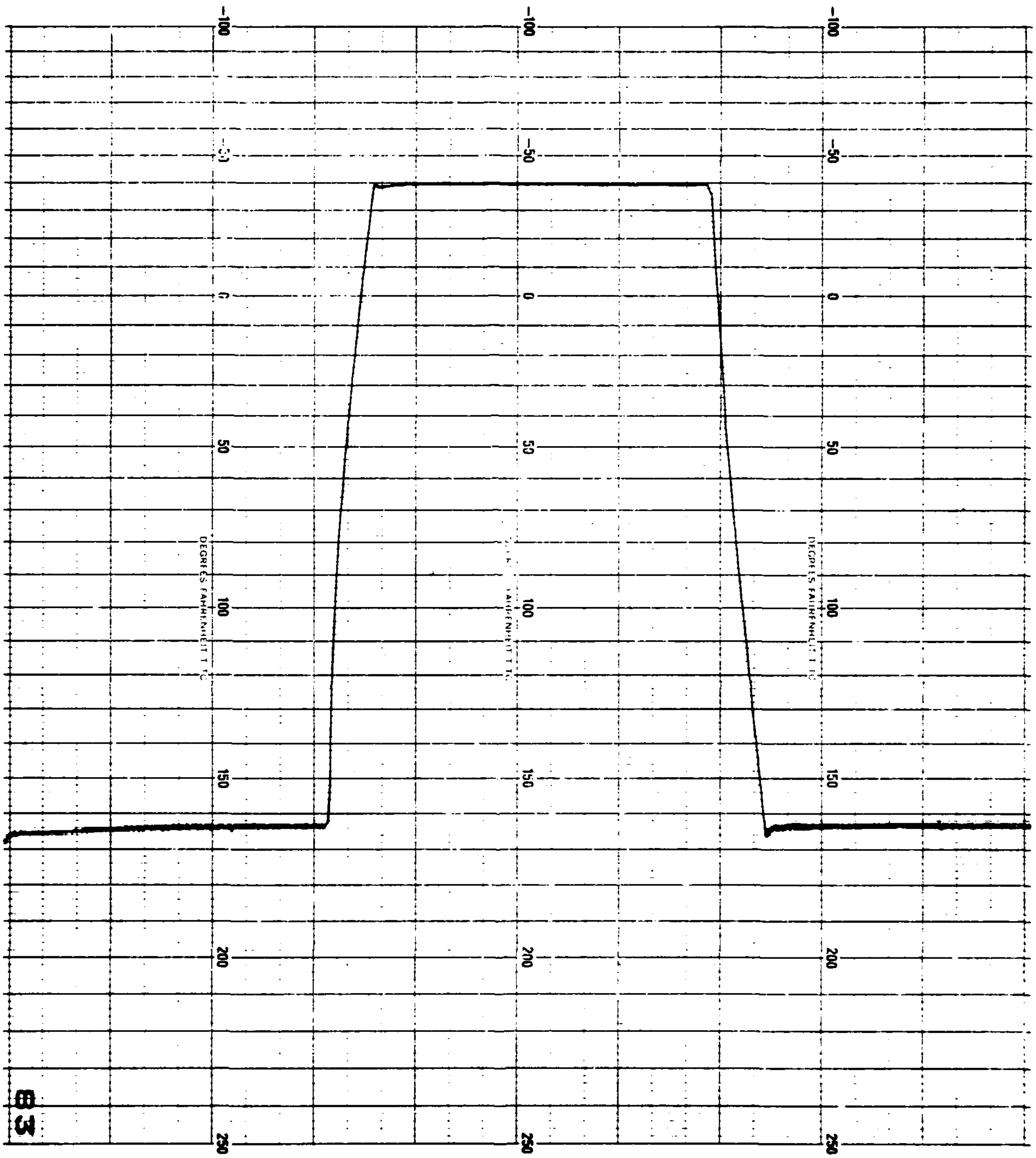


FIGURE H-1
(Sheet 7 of 10)

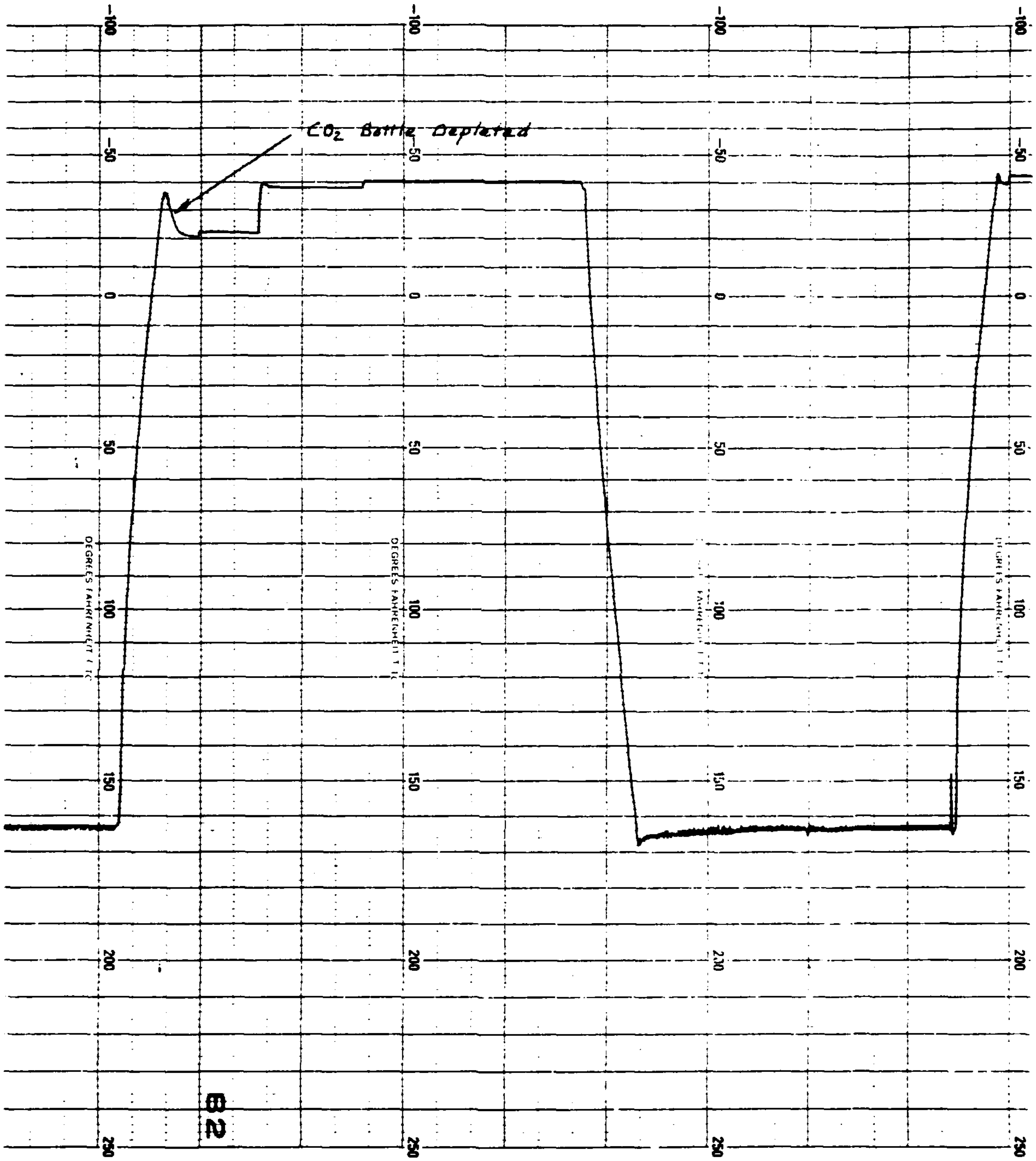


FIGURE H-1
(Sheet 8 of 10)

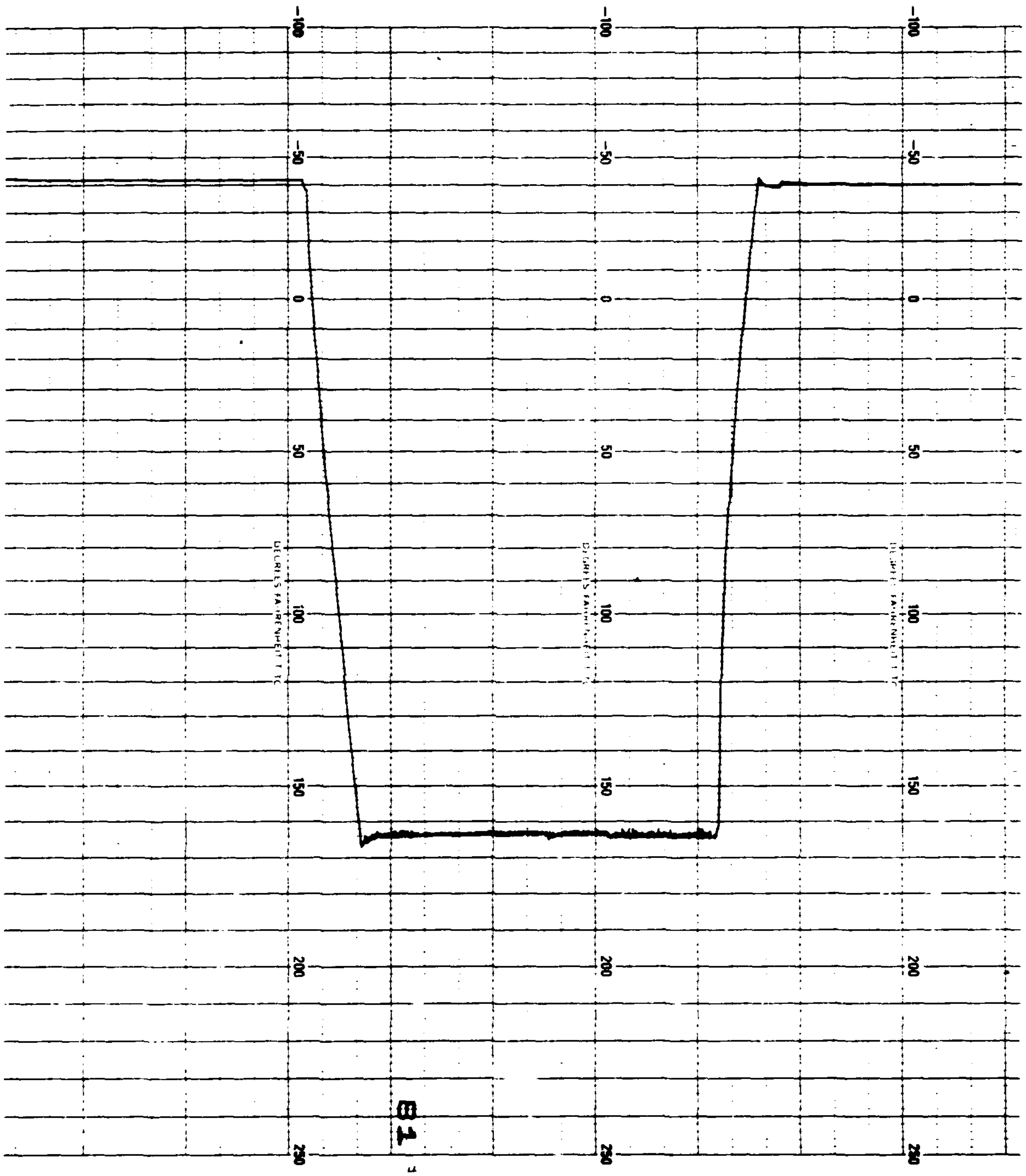


FIGURE H-1
(Sheet 9 of 10)

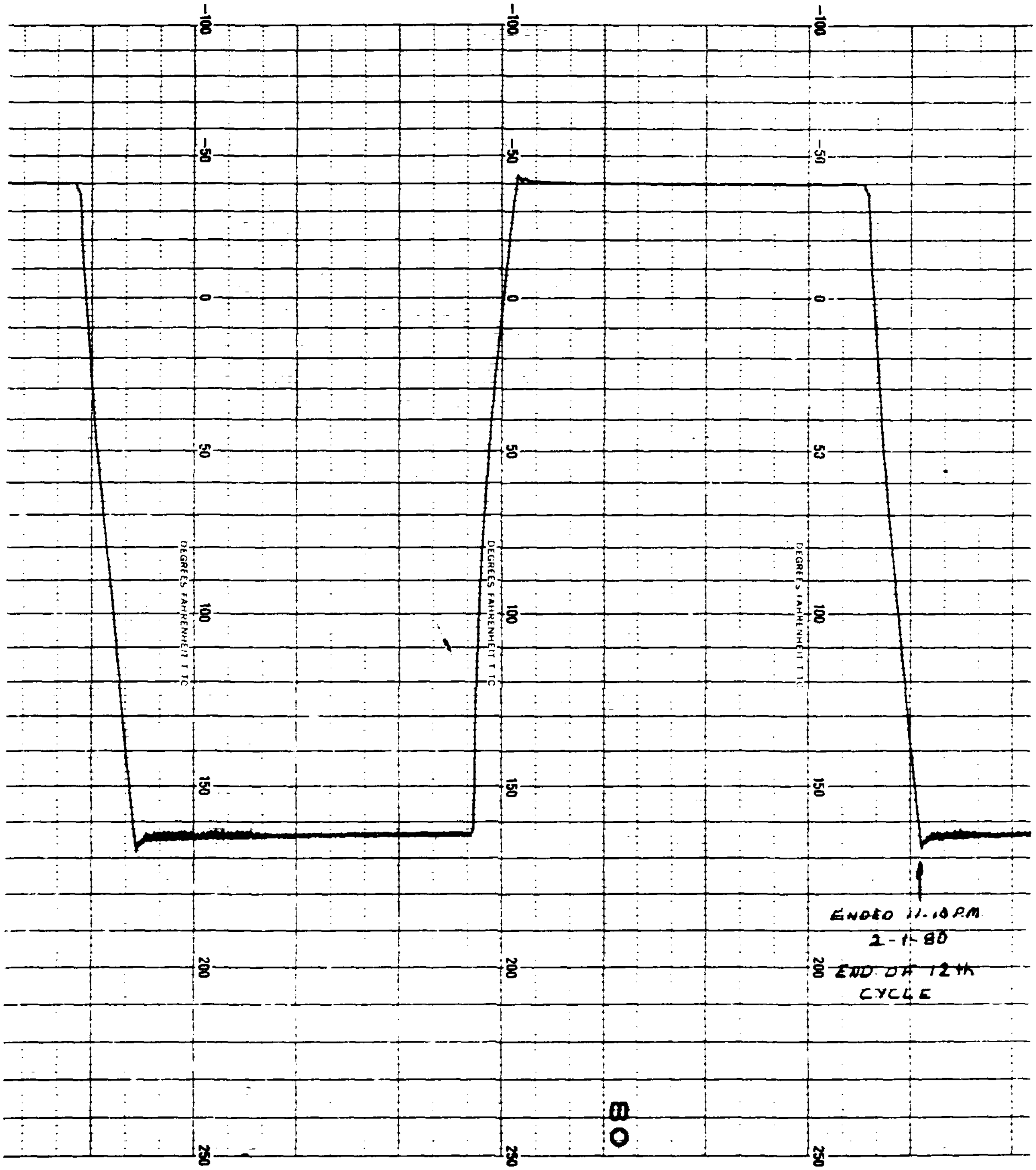


FIGURE H-1
(Sheet 10 of 10)

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX I

APPENDIX I

FUNCTIONAL TESTING OF PLATED INJECTION MOLDED FILTERS

GENERAL DYNAMICS
Pomona Division

TM	6-223-9.18-50
MODEL	
CONTRACT	

TECHNICAL MEMORANDUM

DATE: 9 May 1980

TO: W. L. MacTurk (4-26)

FROM: J. R. Allen

SUBJECT:

Test Report on S-13 Injection Molded Filters

REFERENCE:

DISTRIBUTION:
LIBRARY

PREPARED BY: J. R. Allen
J. R. Allen

Reviewed By: J. F. Godfrey
J. F. Godfrey

REVIEWED BY: R. M. Haner
R. M. Haner

APPROVED BY: E. Tahan
E. Tahan, Section Head
Microwave and Antennas

GD FORM 6-660 R?

1. INTRODUCTION

This test program was conducted to evaluate the performance of injection molded filters produced on contract N66001-79-C-0022WJC.

Seven filters were subjected to a test program consisting of temperature, vibration, shock and humidity.

All filters met the electrical specifications outlined in the test plan, CDRL A005, when tested to the environments as described herein.

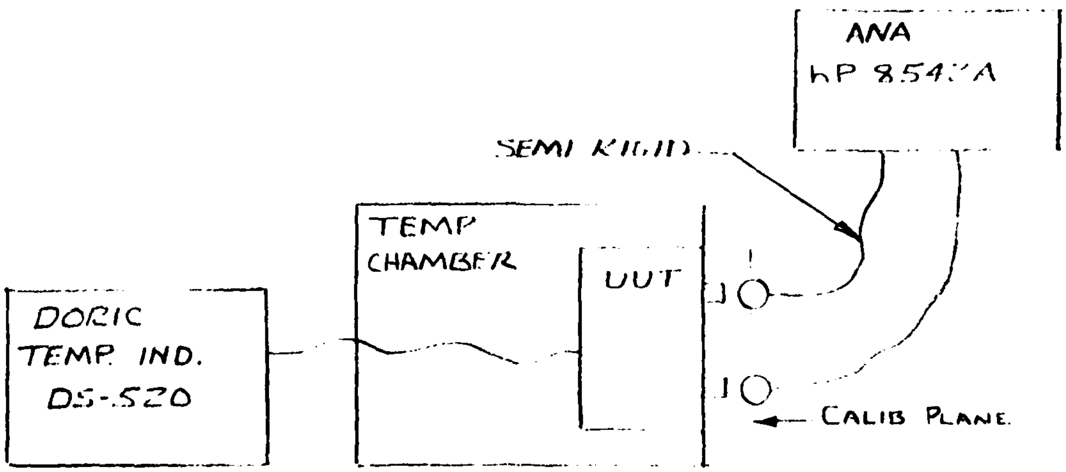
2. TEST SAMPLES

The three filters submitted for test were equivalent to GD/P part number 5188423 S-13 combline bandpass filters except they were injection molded using GE's Valox 420 SEO. The filters were tuned using conventional tuning techniques. After tuning, the tuning screws were locked with epoxy. No further adjustment was made during the test program.

3. TEST PROCEDURES AND RESULTS

3.1 TEMPERATURE TEST

The test equipment was set up as follows:

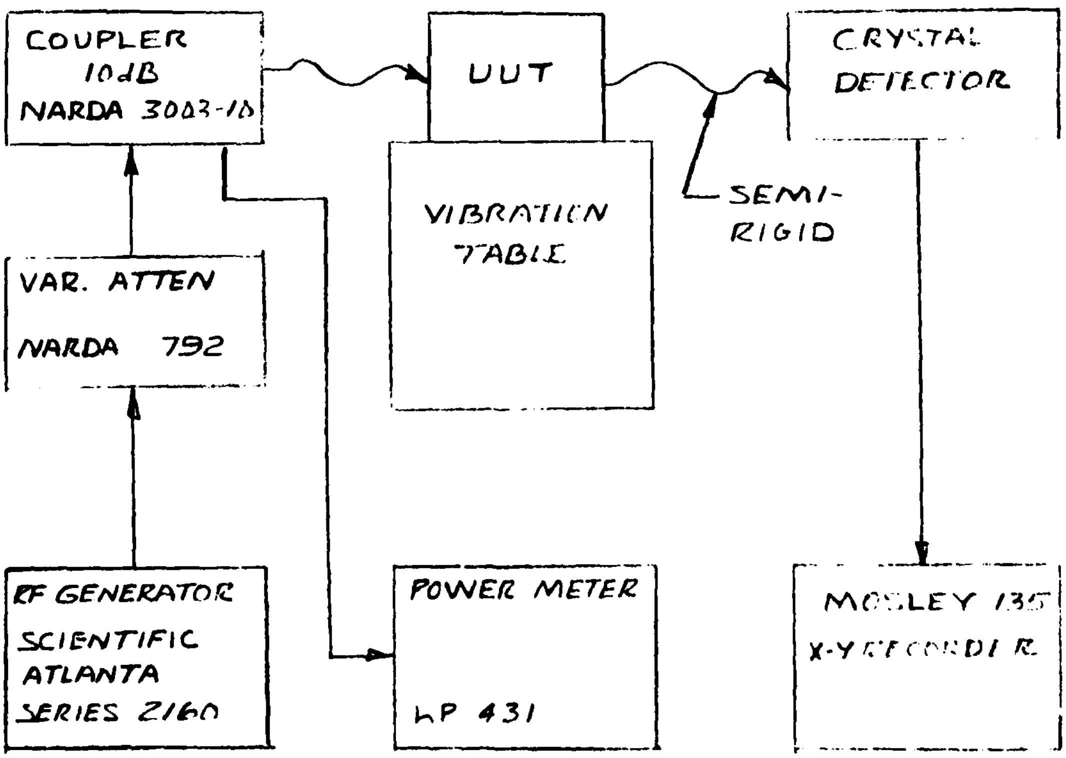


The automatic network analyzer was calibrated to the ends of the semi-rigid cable using standard practices. After calibration the first UUT was placed in the chamber and connected to the semi-rigid cables. A thermocouple was attached to the body of the filter. Baseline VSWR and insertion loss data was taken on the ANA at room ambient. The chamber temperature was then lowered to 40°F. When the UUT reached 40°F VSWR and insertion loss data was again taken on the ANA. The chamber temperature was then raised to 150°F. When the UUT reached the test temperature VSWR and insertion loss data was obtained using the ANA.

This test sequence was repeated for the second and third filter. Test data are present in Annex A.

3.2 VIBRATION

The test equipment was set up as follows:



The X-Y recorder was calibrated such that it displayed a 2 dB power variation over 4 1/2 inches in the Y-axis. The X-axis was adjusted for a full scale sweep of 3 minutes. The UUT was installed on the vibration table and power was applied at frequency F_o. The attenuator was adjusted such that the power level displayed was mid-scale on the X-Y recorder. Random vibration of 5.4 gRms 20 to 2000 Hz corresponding to curve AE figure 514-2-5, procedure VII of MIL-STD-810C was applied to the filter under test for 30 minutes. A 3 minute recording was made of insertion loss at the beginning and end of the vibration run. Without removing the UUT, vibration was switched to sinusoidal in accordance with curve P, figure 514-2-5, MIL-STD-810C (5 g's). The sine sweep was applied for 30 minutes. A 3 minute recording of insertion loss was made at the beginning and end of the run.

The vibration test was repeated a total of three times for three mutually perpendicular axes.

The second and third filters were also vibrated as described above.

One of the three filters exhibited large variation in insertion loss during random vibration. Subsequent investigation showed that one of the solder joints on the connector center conductor cracked. This filter was replaced with another unit and the complete vibration test was repeated.

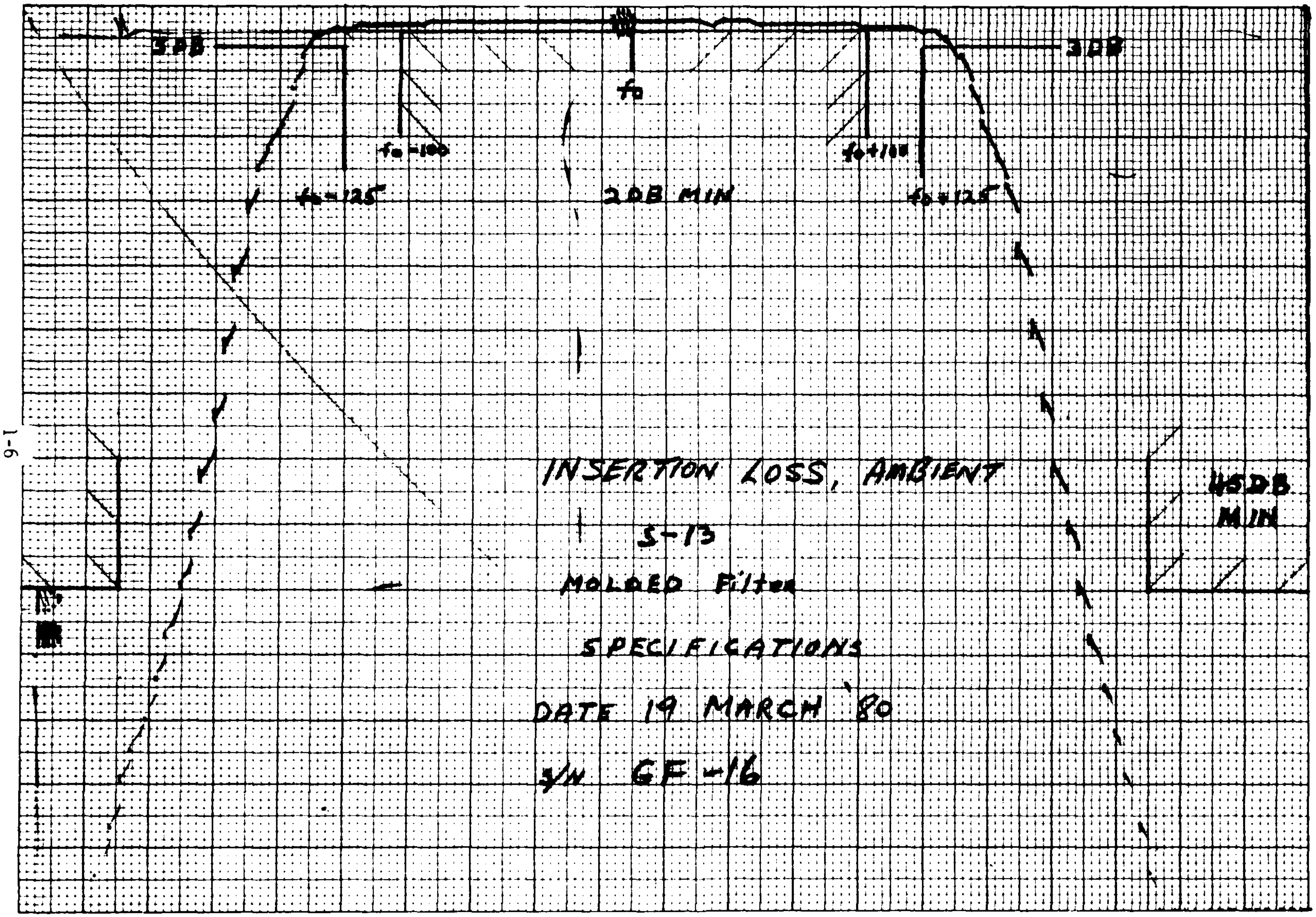
Two of the original filters and the replacement third filter exhibited NO variation in insertion loss as a result of vibration.

Test data are enclosed in Annex B.

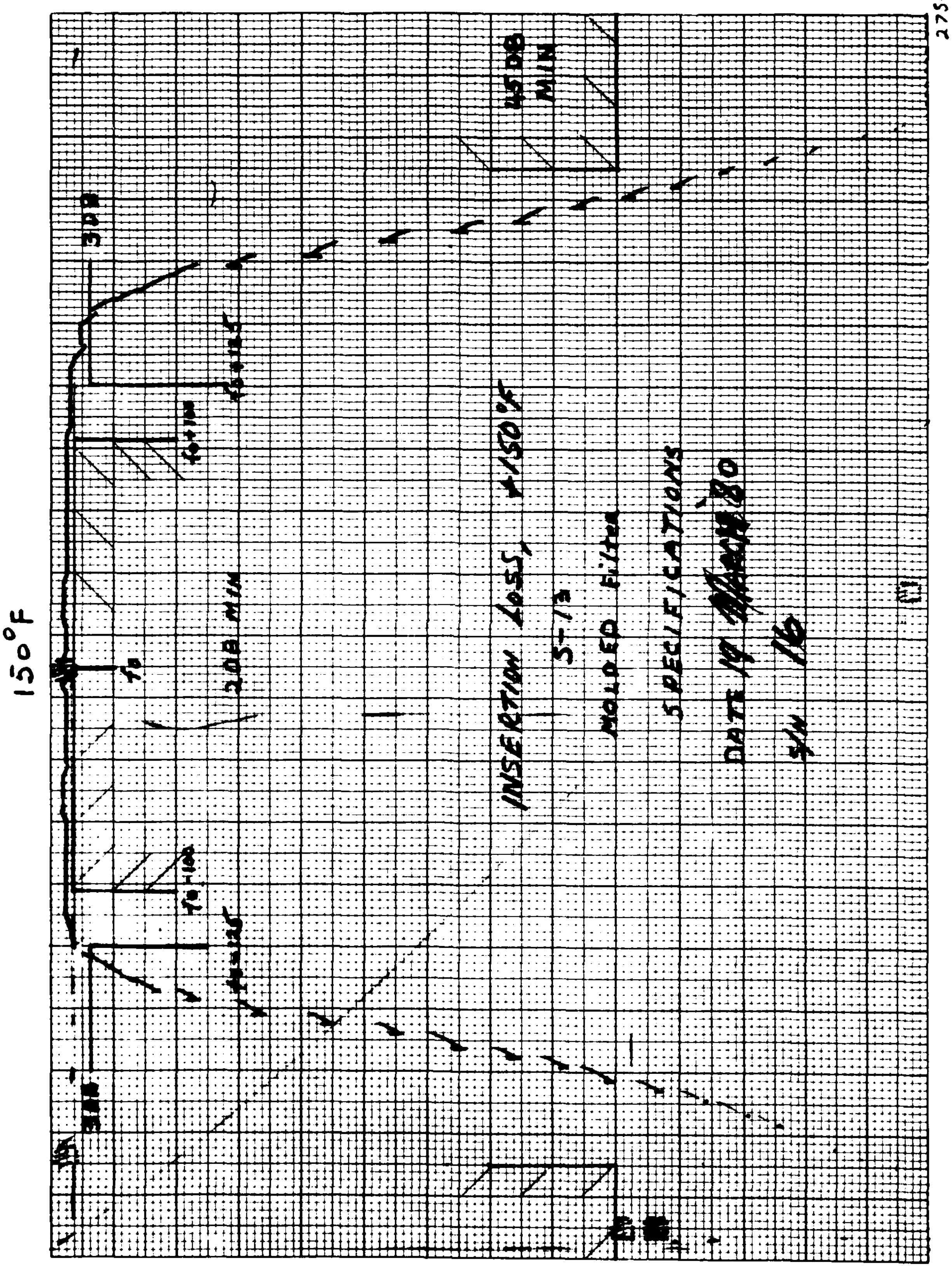
ANNEX A

TEMPERATURE TEST DATA

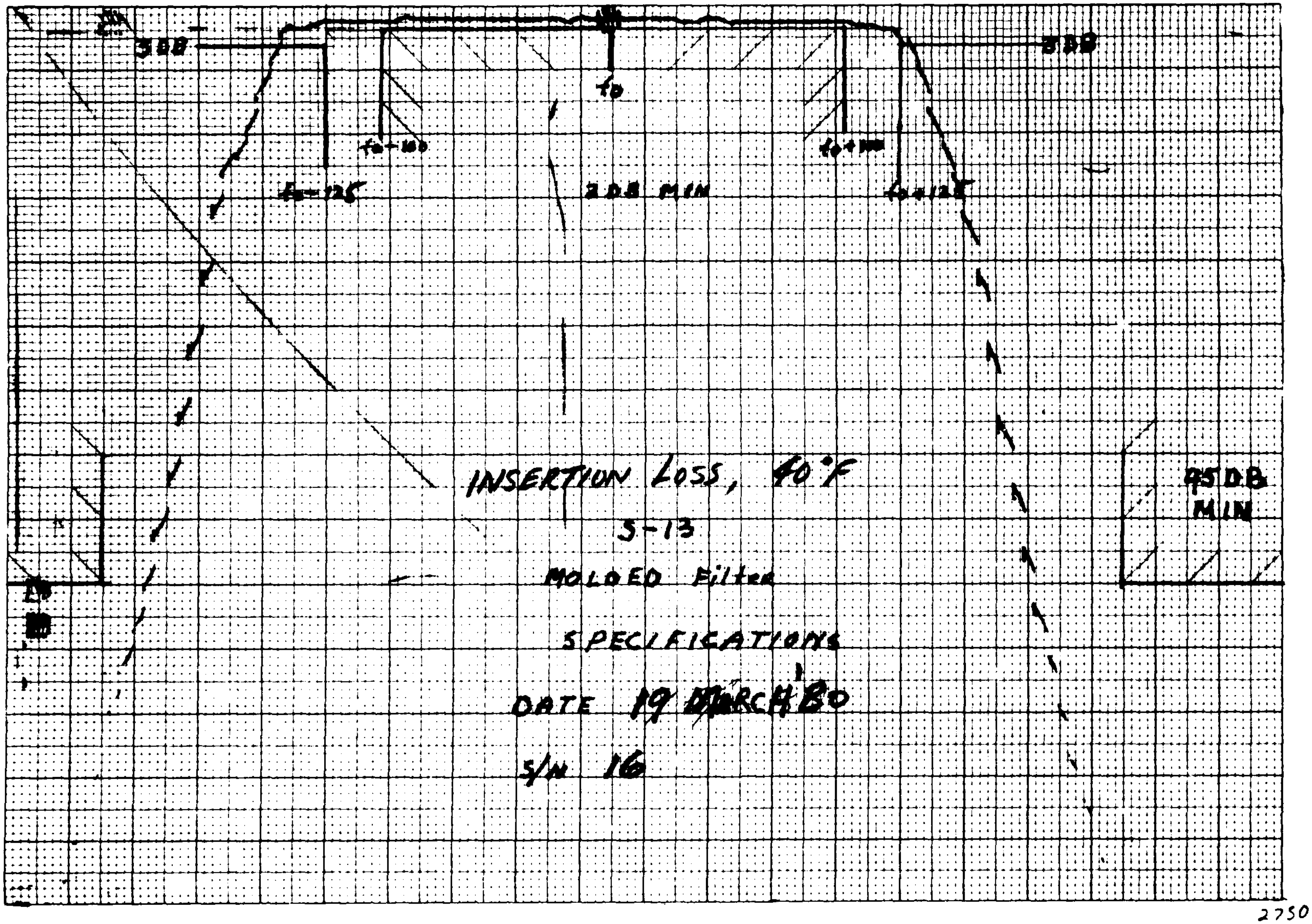
AMBIENT - 70°F



2750


150°F
INSERTION LOSS, +150°F
S-13
MOLDED Filter
SPECIFICATIONS
DATE 19 March 80
S/N 16
45DB MIN
2DB MIN
3DB
2750

40°F



3DB
3DB
fo
fo-100
fo+100
fo-125
fo+125
2DB MIN
45DB
MIN
INSERTION LOSS, 40°F
S-13
MOLDED Filter
SPECIFICATIONS
DATE 19 MARCH 80
S/N 16
2750

3.3 SHOCK

Each filter was subjected to three shocks in each direction along three mutually perpendicular axes for a total of 18 shocks. The shock pulse shape, acceleration and duration was half sine wave, 40 g's with 11 milliseconds duration.

ANA data taken before and after the shock indicated no degradation in performance as a result of exposure to this environment.

Test data is enclosed in Appendix C.

3.4 HUMIDITY

The three filters were exposed to 95% relative humidity at temperatures ranging from $86^{\circ}F$ to $140^{\circ}F$ for a total of 111 hours.

Humidity cycling profile and before and after RF test data is enclosed in Appendix D.

The filters showed no degradation in performance as a result of exposure to this environment.

03/19/80
MOLDED S-13 FILTER
GOLD PLATE
OF16

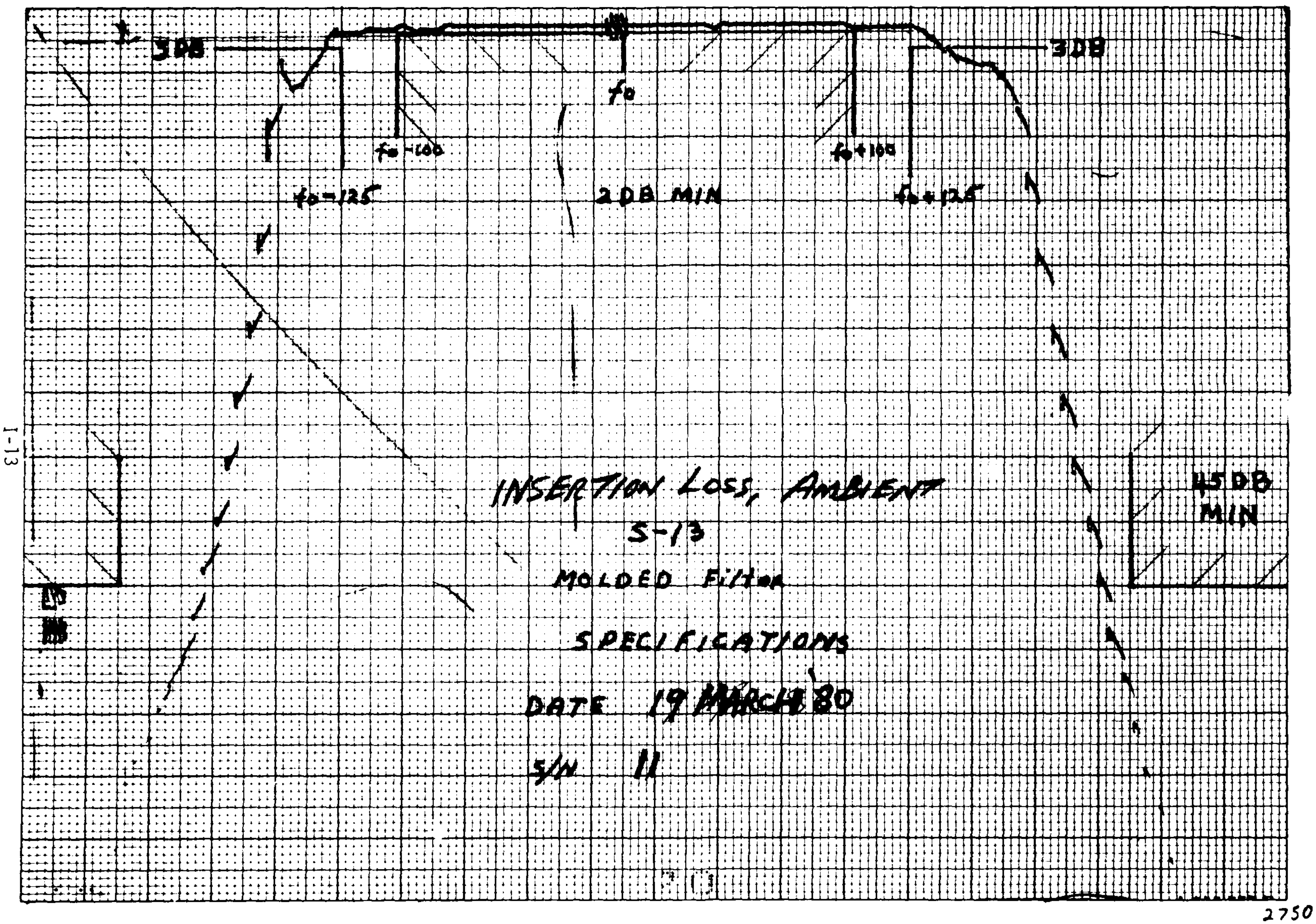
FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
		amb - 71°F		40°F		150°F
00.00	49.35	78.87	48.34	74.92	40.43	78.77
05.00	51.92	74.44	51.79	70.86	42.49	75.46
10.00	52.16	73.92	50.13	70.57	42.13	73.71
15.00	51.50	75.41	48.95	70.77	41.58	70.24
20.00	55.67	73.17	52.58	68.28	43.37	75.41
25.00	48.74	70.11	47.51	65.28	39.73	75.05
30.00	48.17	66.96	48.70	62.02	38.71	71.50
35.00	46.62	63.31	47.44	58.11	39.36	67.29
40.00	49.10	59.62	48.40	55.16	40.70	64.64
45.00	52.29	57.42	49.55	52.12	42.57	62.59
50.00	55.21	54.86	51.57	48.91	47.22	60.65
55.00	51.79	51.94	44.68	45.42	46.71	58.11
60.00	49.33	48.51	41.57	41.64	44.77	55.61
65.00	44.87	44.81	33.70	37.33	41.91	52.24
70.00	38.87	40.90	26.55	32.65	39.03	48.71
75.00	31.33	36.56	18.27	27.43	36.34	45.10
80.00	22.65	31.75	10.06	21.77	31.97	41.28
85.00	14.22	26.51	5.42	16.52	25.69	37.19
90.00	7.31	20.83	3.73	13.34	19.75	32.04
95.00	3.89	15.68	5.34	11.00	12.79	27.91
00.00	4.28	12.55	7.40	9.90	7.22	22.54
05.00	6.44	10.76	7.32	7.36	3.99	16.99
10.00	7.22	8.77	5.08	4.46	3.43	11.78
15.00	5.46	6.23	2.71	2.45	4.42	8.60
20.00	3.14	3.73	1.45	1.89	4.51	6.69
25.00	1.65	2.18	1.53	1.76	3.33	4.87
30.00	1.27	1.71	1.01	1.52	2.07	3.16
35.00	1.50	1.57	1.70	1.29	1.33	2.07
40.00	1.72	1.39	1.48	1.15	1.22	1.64
45.00	1.57	1.23	1.15	1.16	1.42	1.46
50.00	1.32	1.16	1.13	1.22	1.48	1.35
55.00	1.12	1.18	1.38	1.23	1.40	1.25
60.00	1.21	1.17	1.50	1.19	1.24	1.22
65.00	1.41	1.20	1.60	1.12	1.10	1.23
70.00	1.55	1.14	1.67	1.06	1.14	1.24
75.00	1.62	1.09	1.59	1.04	1.27	1.20
80.00	1.60	1.06	1.47	.98	1.39	1.18
85.00	1.52	1.01	1.37	.92	1.47	1.14
90.00	1.43	.94	1.31	.90	1.51	1.12
95.00	1.34	.92	1.28	.91	1.50	1.07
00.00	1.29	.90	1.29	.91	1.46	1.01
05.00	1.29	.92	1.31	.95	1.42	1.02
10.00	1.32	.94	1.34	.95	1.37	1.03
15.00	1.36	.97	1.35	.95	1.34	1.10
20.00	1.39	1.02	1.36	1.01	1.33	1.13
25.00	1.41	.99	1.35	1.01	1.34	1.15
30.00	1.41	1.01	1.33	1.06	1.35	1.11
35.00	1.39	1.04	1.31	1.08	1.35	1.13
40.00	1.35	1.09	1.30	1.11	1.35	1.14
45.00	1.31	1.07	1.27	1.08	1.33	1.14
50.00	1.27	1.05	1.24	1.07	1.31	1.09
55.00	1.22	1.05	1.19	1.04	1.20	1.10

GF16

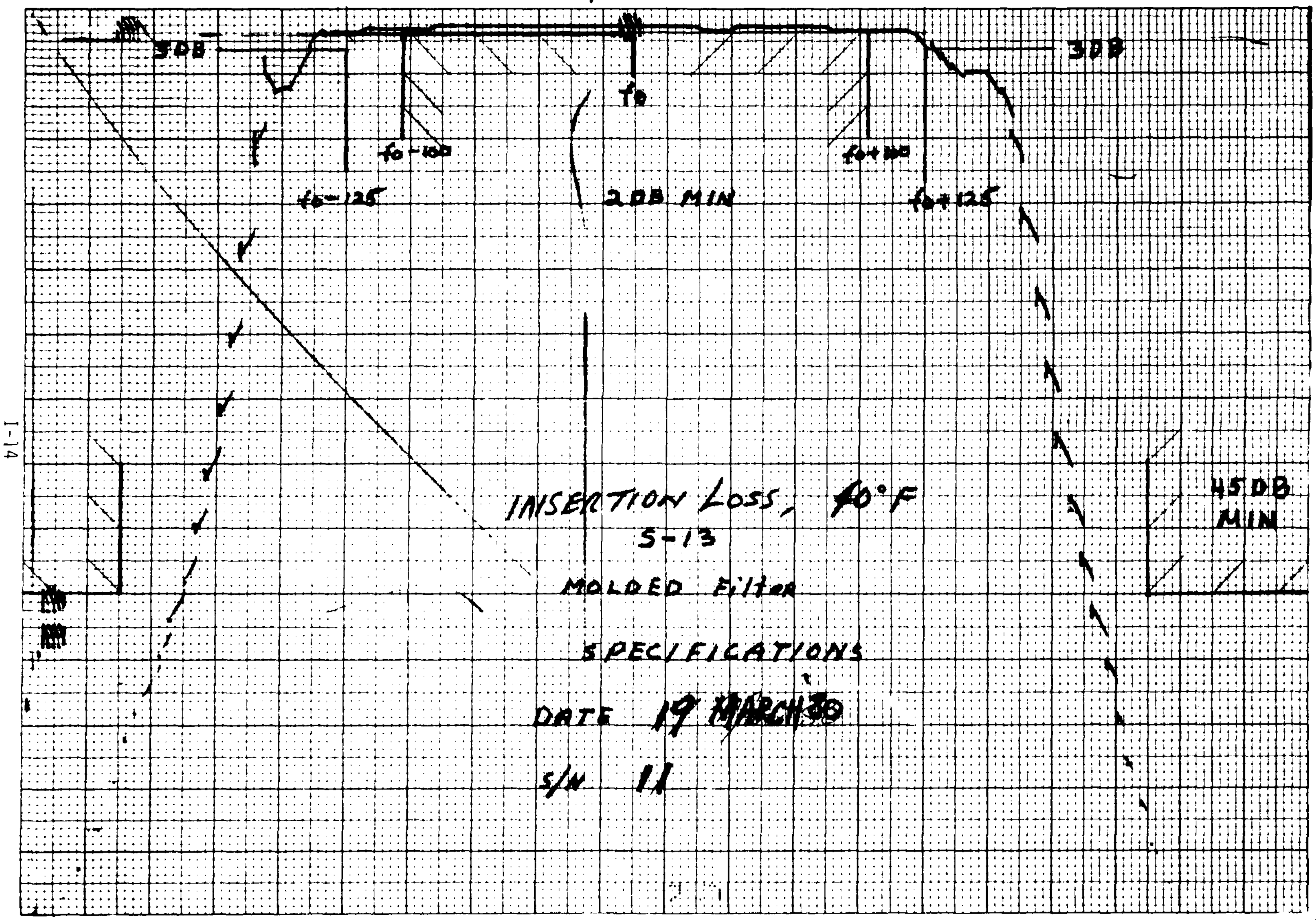
FREQ MHZ	VSNR	LOSS DB	VSNR	LOSS DB	VSNR	LOSS DB
	AMB			40°F		170°F
60.00	1.18	1.04	1.15	1.00	1.25	1.07
65.00	1.14	1.01	1.10	.99	1.22	1.10
70.00	1.09	.96	1.08	.98	1.18	1.11
75.00	1.06	.95	1.12	.99	1.12	1.10
80.00	1.09	.97	1.21	1.05	1.06	1.08
85.00	1.17	.96	1.32	1.09	1.01	1.04
90.00	1.26	1.03	1.41	1.16	1.09	1.05
95.00	1.35	1.11	1.48	1.12	1.18	1.09
00.00	1.43	1.08	1.50	1.06	1.29	1.15
05.00	1.48	1.09	1.40	1.09	1.40	1.10
10.00	1.50	1.08	1.41	1.11	1.50	1.17
15.00	1.47	1.10	1.33	1.14	1.58	1.17
20.00	1.41	1.14	1.30	1.19	1.59	1.22
25.00	1.32	1.17	1.31	1.22	1.58	1.23
30.00	1.26	1.22	1.37	1.22	1.50	1.33
35.00	1.26	1.21	1.44	1.24	1.40	1.35
40.00	1.33	1.19	1.46	1.30	1.29	1.33
45.00	1.41	1.22	1.42	1.36	1.24	1.29
50.00	1.47	1.29	1.33	1.37	1.29	1.24
55.00	1.47	1.35	1.22	1.35	1.42	1.27
60.00	1.39	1.39	1.16	1.34	1.52	1.30
65.00	1.25	1.40	1.24	1.41	1.57	1.51
70.00	1.14	1.39	1.29	1.55	1.51	1.50
75.00	1.20	1.42	1.20	1.71	1.38	1.63
80.00	1.31	1.57	1.11	1.91	1.21	1.50
85.00	1.31	1.70	1.80	2.69	1.22	1.51
90.00	1.15	1.84	3.45	4.83	1.44	1.61
95.00	1.43	2.21	6.26	7.98	1.65	1.91
00.00	2.68	3.68	9.44	10.90	1.60	2.20
05.00	4.07	6.23	12.46	13.31	1.44	2.20
10.00	7.77	9.01	15.10	16.25	1.22	2.26
15.00	10.69	11.37	17.96	20.93	2.04	3.04
20.00	13.71	13.94	20.00	26.77	3.70	4.97
25.00	17.26	18.41	22.19	32.53	5.92	7.00
30.00	20.65	24.35	23.72	37.71	9.13	9.49
35.00	23.26	30.16	26.19	42.55	13.66	13.96
40.00	24.00	35.41	27.58	47.02	17.32	20.40
45.00	23.90	40.19	26.71	50.93	18.90	26.40
50.00	23.98	44.65	26.34	54.91	19.70	32.06
55.00	23.49	48.73	25.90	58.52	20.11	37.03
60.00	23.40	52.64	26.11	62.20	20.26	41.61
65.00	24.01	56.29	26.05	65.49	20.72	45.79
70.00	23.54	59.46	26.07	68.03	20.35	49.71
75.00	24.54	63.29	27.68	73.07	21.38	53.56
80.00	24.69	67.23	20.37	78.71	21.50	57.12
85.00	25.24	70.59	28.17	78.80	21.66	60.41
90.00	25.69	75.09	28.57	80.01	22.33	64.37
95.00	27.18	76.14	29.47	81.95	23.11	67.40
00.00	27.90	82.54	32.07	86.30	23.36	71.54
05.00	28.71	86.80	33.97	85.69	23.79	73.72
10.00	33.89	86.40	38.14	83.69	27.09	82.05
15.00	37.14	88.11	45.13	79.79	28.01	90.67

	6F16	AMB		40°F		150°F
FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
20.00	41.34	84.81	47.46	82.09	32.15	83.68
25.00	43.83	83.03	51.40	83.77	34.21	90.75
30.00	46.23	78.01	54.99	84.41	35.27	83.40
35.00	48.53	81.67	59.38	83.12	37.66	84.07
40.00	52.35	85.14	64.92	91.01	38.84	96.10
45.00	53.98	82.71	71.09	85.29	41.55	97.03
50.00	60.63	83.73	76.09	88.26	43.75	86.08

AMBIENT - 70°F

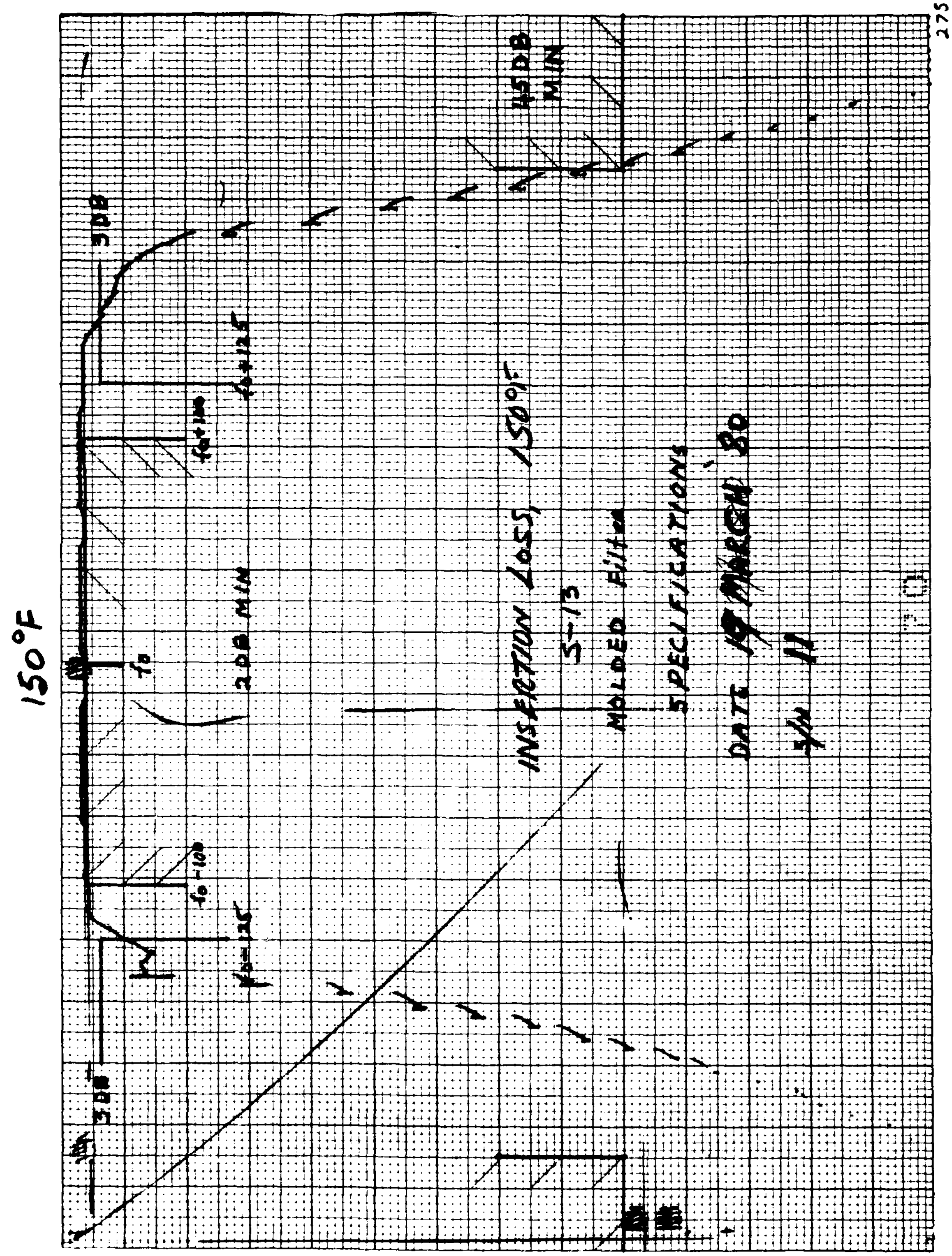

3DB
3DB
f_0
f_0-100
f_0+100
f_0-125
f_0+125
2DB MIN
45DB
MIN
INSERTION LOSS, AMBIENT
5-13
MOLDED Filter
SPECIFICATIONS
DATE 19 MARCH 80
S/N 11
2750

40°F



3DB
3DB
fo
fo-100
fo-125
2DB MIN
fo+100
fo+125
45DB MIN
INSERTION LOSS, 40°F
S-13
MOLDED Filter
SPECIFICATIONS
DATE 19 MARCH 30
S/N 11

2750


150°F
INSERTION LOSS, 150°F
S-13
MOLDED Filter
SPECIFICATIONS
3DB
45DB MIN
2DB MIN
fo
fo+125
fo+100
fo-100
fo-125
2750

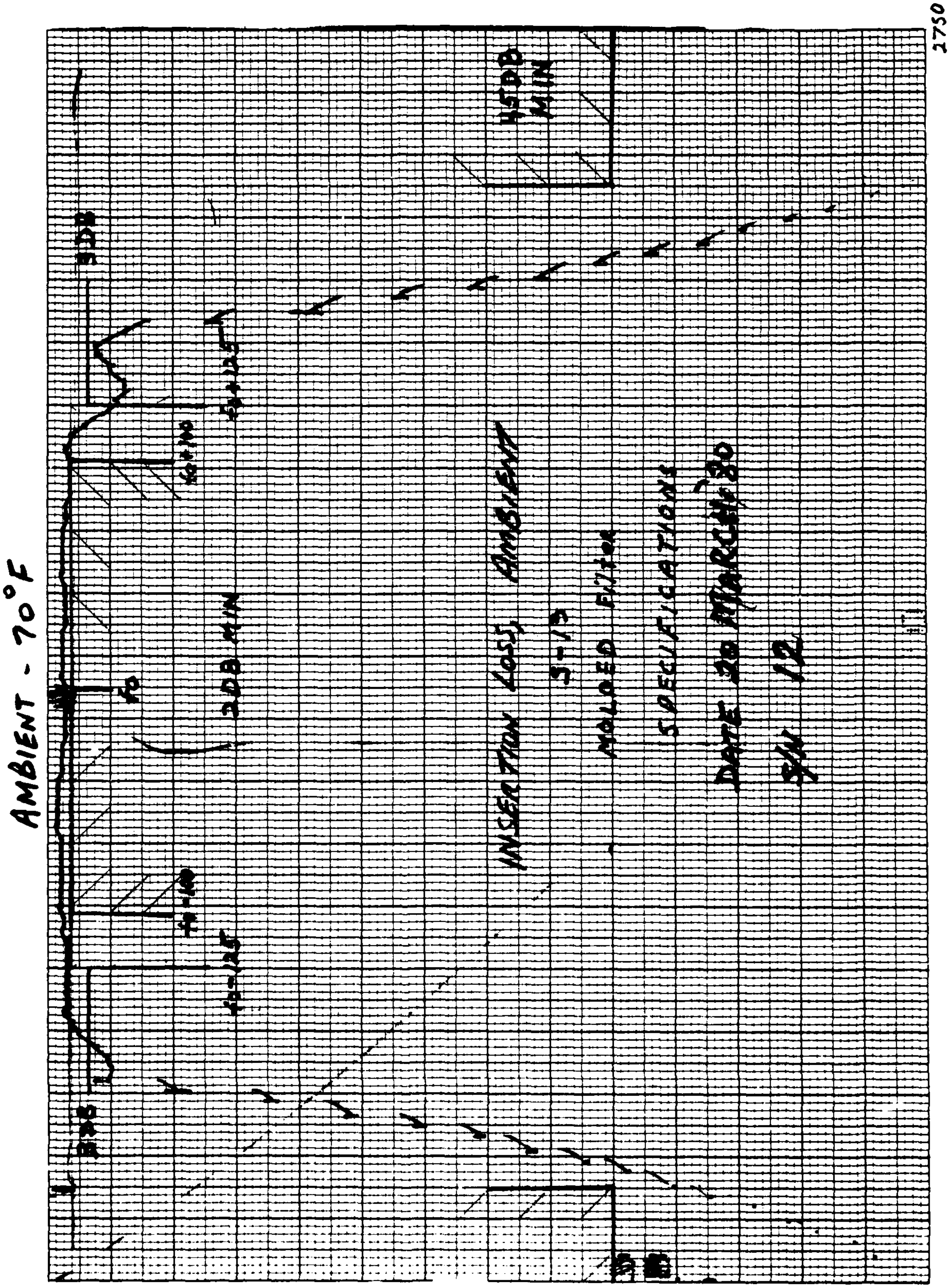
[illegible]
[illegible] FILTER
GOLD PLATE
GF11

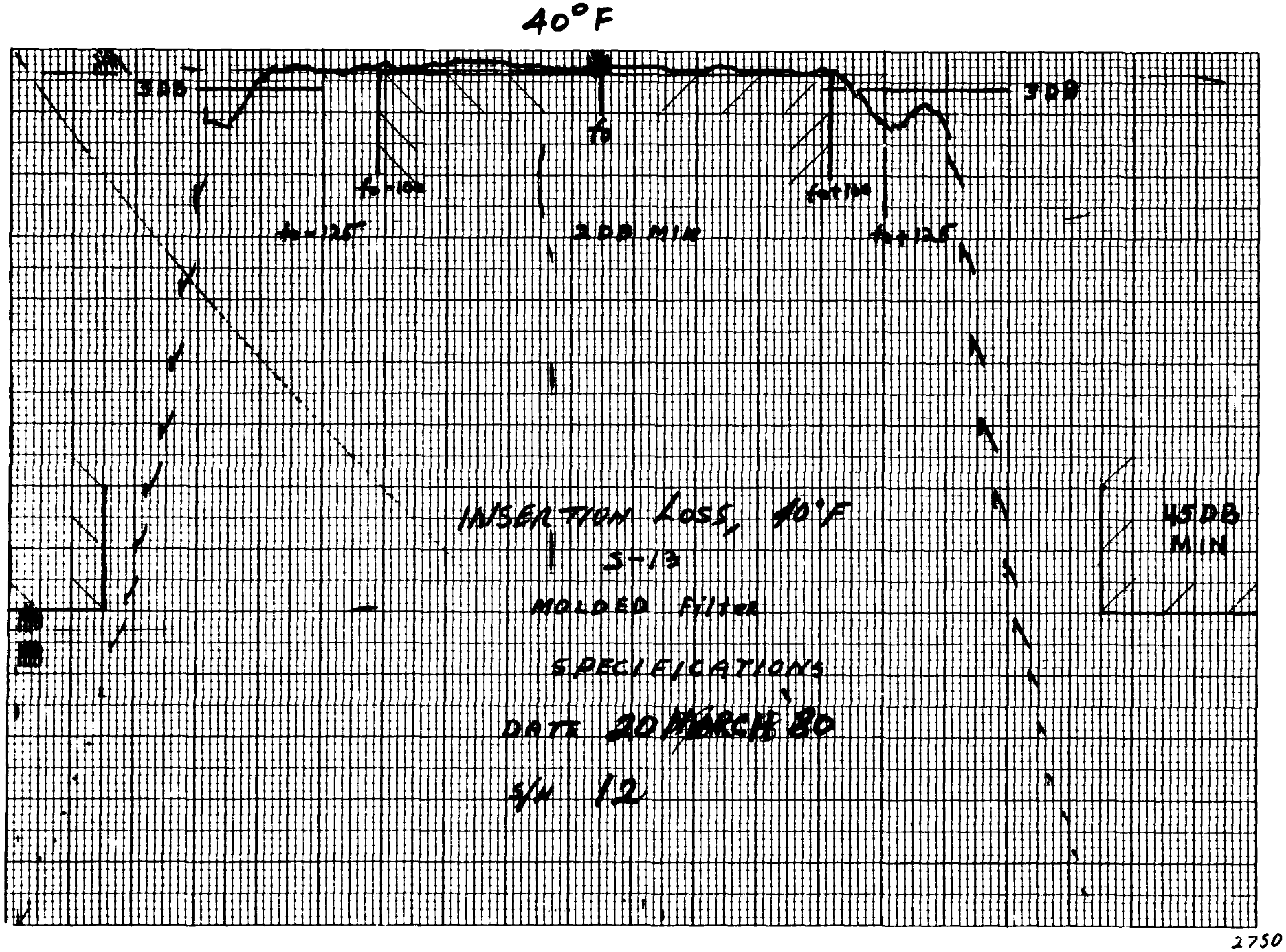
FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	70° F		-40° F		150° F	
00.00	$$$$$$$$$$	69.87	1951.66	69.65	$$$$$$$$$$	81.70
05.00	803.51	72.73	429.03	72.35	521.51	78.14
10.00	401.96	68.55	299.05	72.42	289.96	79.39
15.00	329.33	70.39	255.40	68.49	237.57	73.41
20.00	198.31	68.56	174.38	66.31	161.38	74.88
25.00	216.54	68.48	171.50	63.39	140.19	73.93
30.00	130.97	68.64	161.88	63.27	110.58	73.10
35.00	98.37	65.53	96.14	59.77	93.68	71.29
40.00	84.55	60.30	78.01	56.42	70.78	69.53
45.00	79.70	58.73	75.09	54.37	68.68	67.73
50.00	71.37	56.[illegible]	66.41	52.44	64.29	66.14
55.00	65.95	54.65	61.06	49.94	63.10	63.14
60.00	65.30	52.66	57.07	47.24	67.58	60.59
65.00	62.63	50.52	51.05	44.00	66.61	58.62
70.00	56.20	47.45	46.42	40.44	57.55	55.77
75.00	49.26	43.90	39.84	36.10	54.16	52.46
80.00	43.86	40.10	32.33	31.36	56.37	49.23
85.00	38.00	35.74	27.50	25.74	45.57	45.55
90.00	31.33	30.87	19.80	19.00	40.10	41.95
95.00	24.53	25.23	10.47	10.39	35.93	37.91
00.00	16.01	18.39	2.10	4.60	30.00	33.53
05.00	5.51	9.49	1.61	6.14	25.79	28.72
10.00	2.08	4.49	5.49	5.95	16.77	22.73
15.00	4.08	5.06	4.64	4.44	6.17	15.24
20.00	5.03	5.53	3.12	2.66	2.70	5.44
25.00	3.67	4.03	1.78	1.72	4.79	6.66
30.00	2.20	2.40	1.20	1.53	4.84	6.75
35.00	1.30	1.60	1.38	1.47	3.49	5.43
40.00	1.15	1.46	1.50	1.41	2.21	3.36
45.00	1.38	1.44	1.43	1.30	1.47	2.14
50.00	1.41	1.26	1.28	1.16	1.22	1.91
55.00	1.38	1.21	1.23	1.13	1.30	1.86
60.00	1.18	1.10	1.33	1.13	1.35	1.71
65.00	1.19	1.08	1.45	1.17	1.31	1.56
70.00	1.30	1.14	1.52	1.15	1.23	1.57
75.00	1.40	1.12	1.51	1.09	1.15	1.58
80.00	1.45	1.14	1.45	1.03	1.16	1.58
85.00	1.44	1.07	1.36	.94	1.23	1.47
90.00	1.39	.99	1.27	.96	1.36	1.36
95.00	1.31	.91	1.22	.85	1.35	1.32
00.00	1.21	.91	1.23	.99	1.34	1.27
05.00	1.17	.88	1.30	.87	1.29	1.27
10.00	1.20	.86	1.38	.85	1.20	1.29
15.00	1.28	.85	1.46	.90	1.13	1.26
20.00	1.38	.87	1.51	[illegible]	1.14	1.18
25.00	1.45	.94	1.53	[illegible]	1.24	1.14
30.00	1.50	[illegible]	1.52	1.0[illegible]	1.34	1.1[illegible]
35.00	1.51	[illegible]	1.48	[illegible]	1.4[illegible]	1.19
40.00	1.50	1.0[illegible]	1.43	[illegible]	1.48	1.31
45.00	1.46	1.02	1.38	1.0[illegible]	1.50	1.42
50.00	1.42	1.02	1.32	1.01	1.51	1.54
55.00	1.36	1.0[illegible]	[illegible]	[illegible]	1.56	1.[illegible]

6F-11 AMB 40°F 150°F

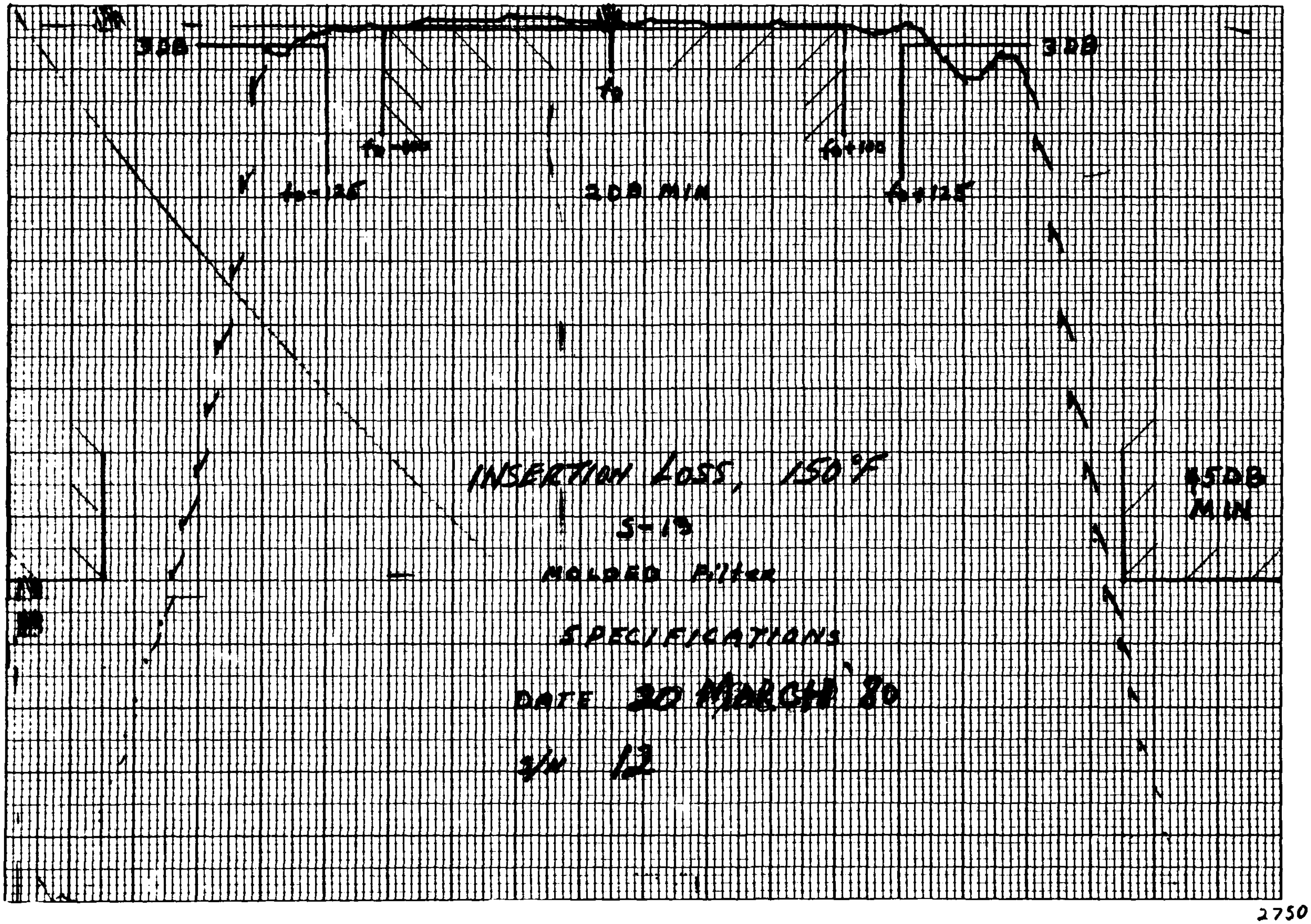
FREQ MHZ	VSWR	LOSS DB	VSRR	LOSS DB	VSRR	LOSS DB
60.00	1.29	1.03	1.20	.93	1.48	1.41
65.00	1.21	.97	1.16	.86	1.45	1.29
70.00	1.14	.90	1.18	.83	1.37	1.17
75.00	1.10	.87	1.22	.89	1.28	1.15
80.00	1.15	.86	1.29	.92	1.16	1.14
85.00	1.23	.91	1.35	1.00	1.06	1.15
90.00	1.32	.97	1.40	1.11	1.13	1.15
95.00	1.39	1.03	1.43	1.13	1.26	1.14
00.00	1.43	1.05	1.42	1.10	1.39	1.12
05.00	1.43	1.08	1.38	1.05	1.47	1.22
10.00	1.48	1.07	1.31	.99	1.49	1.34
15.00	1.33	1.05	1.22	.93	1.47	1.44
20.00	1.25	.95	1.15	90	1.86	1.46
25.00	1.19	.89	1.17	.93	1.79	1.44
30.00	1.16	.87	1.22	96	1.66	1.28
35.00	1.16	.91	1.28	1.01	1.52	1.18
40.00	1.19	.99	1.33	1.04	1.44	1.21
45.00	1.23	1.03	1.39	1.10	1.41	1.32
50.00	1.28	1.05	1.45	1.15	1.41	1.34
55.00	1.34	1.09	1.48	1.20	1.41	1.32
60.00	1.42	1.12	1.48	1.29	1.43	1.29
65.00	1.49	1.20	1.39	1.23	1.46	1.29
70.00	1.51	1.28	1.27	1.20	1.48	1.37
75.00	1.44	1.29	1.27	1.26	1.45	1.48
80.00	1.29	1.24	1.62	1.59	1.37	1.51
85.00	1.17	1.25	2.22	2.34	1.25	1.49
90.00	1.41	1.47	3.04	3.27	1.13	1.40
95.00	1.95	2.03	3.78	3.99	1.07	1.40
00.00	2.72	2.32	4.15	4.40	1.06	1.50
05.00	3.56	3.65	4.00	4.51	1.20	1.76
10.00	4.11	4.08	3.42	4.63	1.59	2.22
15.00	4.19	4.21	5.16	5.81	2.29	2.80
20.00	3.73	4.34	4.52	3.27	3.30	3.49
25.00	3.21	5.11	8.62	15.05	4.39	4.01
30.00	3.65	7.81	16.13	21.33	5.01	4.24
35.00	6.32	12.39	31.65	27.29	4.67	4.68
40.00	12.69	19.13	61.07	32.75	3.58	5.84
45.00	23.84	25.65	134.13	37.59	2.83	8.35
50.00	41.36	30.57	235.65	47.01	1.81	13.11
55.00	65.58	35.43	423.67	45.16	11.94	19.55
60.00	102.38	40.15	578.04	50.23	26.43	25.70
65.00	136.62	44.50	618.06	54.16	41.47	31.33
70.00	120.00	48.71	188.78	57.87	43.40	36.36
75.00	142.22	52.37	164.03	63.07	42.77	41.03
80.00	178.14	56.18	156.66	64.33	36.32	45.24
85.00	160.32	59.79	193.49	66.59	30.58	49.33
90.00	151.54	62.63	193.58	70.59	24.54	53.07
95.00	140.51	66.90	158.58	75.02	23.36	57.11
00.00	120.84	69.95	177.67	77.67	22.65	60.27
05.00	110.34	77.13	168.58	87.94	22.67	63.21
10.00	105.76	82.42	165.73	83.76	23.47	68.52
15.00	115.57	84.43	112.82	87.83	26.80	69.86

	6F11	AMB	40°F		150°F	
FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
20.00	140.77	55.13	120.80	102.80	35.26	73.54
25.00	164.60	84.93	156.56	83.37	48.03	77.78
30.00	212.21	80.12	167.73	85.28	76.29	78.10
35.00	165.16	83.37	132.67	86.15	130.78	81.03
40.00	164.36	83.67	151.10	90.53	250.37	85.73
45.00	154.32	84.10	122.42	95.87	874.64	86.79
50.00	128.34	87.04	111.47	81.49	365.54	86.80


AMBIENT - 70°F
3DB
45DB MIN
fo+100
fo+125
fo
2DB MIN
fo-100
fo-125
3DB
45DB
INSERTION LOSS, AMBIENT
5-13
MOLDED FILTER
SPECIFICATIONS
DATE 20 MARCH 80
S/N 12
2750


40°F
3DB
3DB
fo
fo-100
fo+100
fo-125
fo+125
2DB MIN
45DB
MIN
INSERTION LOSS, 40°F
S-13
MOLDED Filter
SPECIFICATIONS
DATE 20 MARCH 80
S/N 12
2750

150°F


3DB
3DB
f_0
f_0-100
f_0+100
f_0-125
f_0+125
2DB MIN
45DB
MIN
INSERTION LOSS, 150°F
S-13
MOLDED Filter
SPECIFICATIONS
DATE 20 MARCH '80
S/N 12
2750

03/20/80
[illegible] FILTER
GOLD PLATE
GF12

FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	71° F		40° F		150° F	
00.00	37.92	73.43	28.51	71.63	33.08	76.34
05.00	36.42	70.45	22.01	70.35	31.43	72.61
10.00	37.79	69.46	18.00	68.02	26.89	70.54
15.00	40.94	65.49	15.26	64.66	27.85	67.83
20.00	42.96	63.91	12.96	62.98	28.26	69.52
25.00	44.69	60.81	11.18	60.79	34.31	69.21
30.00	45.31	58.52	9.87	58.18	33.83	69.62
35.00	44.42	55.86	8.92	55.30	33.71	68.39
40.00	45.21	52.57	8.30	51.67	34.30	63.66
45.00	51.18	49.57	8.33	47.97	25.20	66.49
50.00	55.19	46.14	8.57	44.17	42.47	57.08
55.00	63.26	42.69	9.42	40.10	47.96	54.19
60.00	66.81	38.81	11.64	35.69	54.27	51.28
65.00	64.94	34.53	13.94	30.92	60.24	48.13
70.00	53.48	29.89	18.55	25.59	59.75	44.61
75.00	35.73	24.48	21.64	19.50	50.33	40.80
80.00	19.40	18.13	14.57	17.19	59.73	36.60
85.00	6.27	10.40	2.93	5.99	53.76	32.14
90.00	1.19	4.91	1.77	5.82	41.61	27.17
95.00	3.29	4.93	5.21	6.05	23.75	21.49
00.00	4.74	4.82	5.99	5.14	8.72	14.69
05.00	4.11	3.93	4.31	3.77	1.77	7.65
10.00	2.93	2.73	2.62	2.53	2.60	3.58
15.00	2.07	1.94	1.59	1.88	3.69	4.09
20.00	1.54	1.55	1.22	1.69	3.42	3.96
25.00	1.31	1.43	1.27	1.60	2.75	3.19
30.00	1.24	1.49	1.20	1.60	2.15	2.53
35.00	1.26	1.41	1.34	[illegible]	1.76	2.20
40.00	1.35	1.52	1.54	1.90	1.53	2.03
45.00	1.44	1.48	1.71	1.92	1.41	1.93
50.00	1.50	1.37	1.74	1.80	1.36	1.92
55.00	1.51	1.24	1.64	1.59	1.37	1.91
60.00	1.47	1.11	1.44	1.40	1.39	1.86
65.00	1.38	1.03	1.24	1.29	1.59	1.80
70.00	1.27	1.02	1.18	1.33	1.42	1.66
75.00	1.18	1.05	1.29	1.44	1.28	1.49
80.00	1.15	1.00	1.36	1.40	1.18	1.37
85.00	1.19	.93	1.36	1.35	1.19	1.31
90.00	1.26	.97	1.30	1.25	1.16	1.27
95.00	1.32	.85	1.23	1.09	1.21	1.25
00.00	1.36	.83	1.24	1.09	1.22	1.24
05.00	1.38	.74	1.35	.98	1.17	1.20
10.00	1.39	.76	1.48	1.02	1.16	1.15
15.00	1.40	.79	1.57	1.05	1.16	1.09
20.00	1.41	.80	1.59	1.17	1.27	1.08
25.00	1.42	.85	1.55	1.26	1.41	1.07
30.00	1.44	.95	1.48	[illegible]	1.49	1.07
35.00	1.46	1.02	1.41	1.30	1.56	1.09
40.00	1.49	1.14	1.36	1.44	1.47	1.14
45.00	1.50	1.20	1.31	1.45	1.37	1.21
50.00	1.51	1.27	1.29	1.39	1.30	1.27
55.00	1.58	1.25	1.21	[illegible]	1.24	1.37

6F12

FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	AMB		40°F		100°F	
60.00	1.48	1.17	1.35	1.24	1.26	1.47
65.00	1.46	1.08	1.39	1.17	1.29	1.44
70.00	1.43	.99	1.42	1.16	1.33	1.43
75.00	1.39	.99	1.41	1.20	1.36	1.35
80.00	1.36	1.01	1.37	1.25	1.39	1.30
85.00	1.33	1.09	1.37	1.35	1.42	1.28
90.00	1.32	1.15	1.41	1.40	1.44	1.20
95.00	1.34	1.17	1.48	1.43	1.44	1.34
00.00	1.36	1.15	1.54	1.43	1.42	1.40
05.00	1.37	1.11	1.54	1.37	1.41	1.42
10.00	1.36	1.04	1.46	1.31	1.41	1.45
15.00	1.30	1.00	1.34	1.28	1.42	1.44
20.00	1.21	1.02	1.24	1.37	1.50	1.47
25.00	1.17	1.05	1.30	1.42	1.50	1.41
30.00	1.15	1.09	1.43	1.44	1.44	1.37
35.00	1.28	1.11	1.56	1.52	1.33	1.39
40.00	1.45	1.22	1.55	1.63	1.18	1.43
45.00	1.56	1.39	1.51	1.75	1.08	1.46
50.00	1.59	1.49	1.32	1.77	1.18	1.41
55.00	1.50	1.52	1.11	1.62	1.35	1.42
60.00	1.25	1.39	1.33	1.63	1.40	1.51
65.00	1.10	1.3[illegible]	1.81	2.16	1.53	1.74
70.00	1.60	1.61	2.38	3.25	1.52	1.93
75.00	2.41	2.56	2.91	4.47	1.43	1.95
80.00	3.37	3.88	3.33	5.46	1.30	1.83
85.00	4.19	5.16	3.66	5.95	1.22	1.63
90.00	4.59	5.92	3.75	5.76	1.48	1.87
95.00	4.32	5.87	3.42	5.05	2.00	2.73
00.00	3.51	5.03	2.72	4.44	2.70	3.98
05.00	2.48	3.89	2.30	4.88	3.49	5.06
10.00	2.01	3.58	1.30	8.23	4.12	5.69
15.00	3.11	5.93	1.87	15.32	4.25	5.66
20.00	6.62	12.54	2.17	22.73	3.66	4.85
25.00	10.24	20.24	12.27	25.33	2.86	3.83
30.00	12.63	27.1[illegible]	14.68	35.10	2.56	4.07
35.00	14.35	33.10	15.57	44.52	2.36	6.00
40.00	15.44	38.[illegible]	16.66	45.18	3.40	10.35
45.00	16.87	42.[illegible]	16.27	42.49	7.00	17.17
50.00	16.99	47.[illegible]	15.63	53.49	10.61	24.03
55.00	17.55	51.[illegible]	17.93	57.45	12.10	30.18
60.00	17.66	54.61	12.47	60.44	11.71	35.64
65.00	17.97	58.17	11.51	63.49	10.78	40.70
70.00	17.87	61.[illegible]1	10.82	66.71	10.02	45.22
75.00	18.48	64.87	10.57	69.[illegible]	9.40	49.48
80.00	19.60	67.51	10.67	72.05	8.93	53.17
85.00	21.10	71.[illegible]5	10.96	61.01	8.83	57.17
90.00	22.14	77.53	11.30	85.48	8.89	60.73
95.00	22.84	81.[illegible]	12.63	84.07	9.09	64.36
00.00	24.15	86.[illegible]4	13.33	85.52	9.67	68.23
05.00	24.90	91.[illegible]1	14.98	83.87	10.53	71.55
10.00	28.01	97.[illegible]	18.20	85.16	11.87	77.61
15.00	29.77	83.[illegible]	22.57	87.22	13.61	78.79

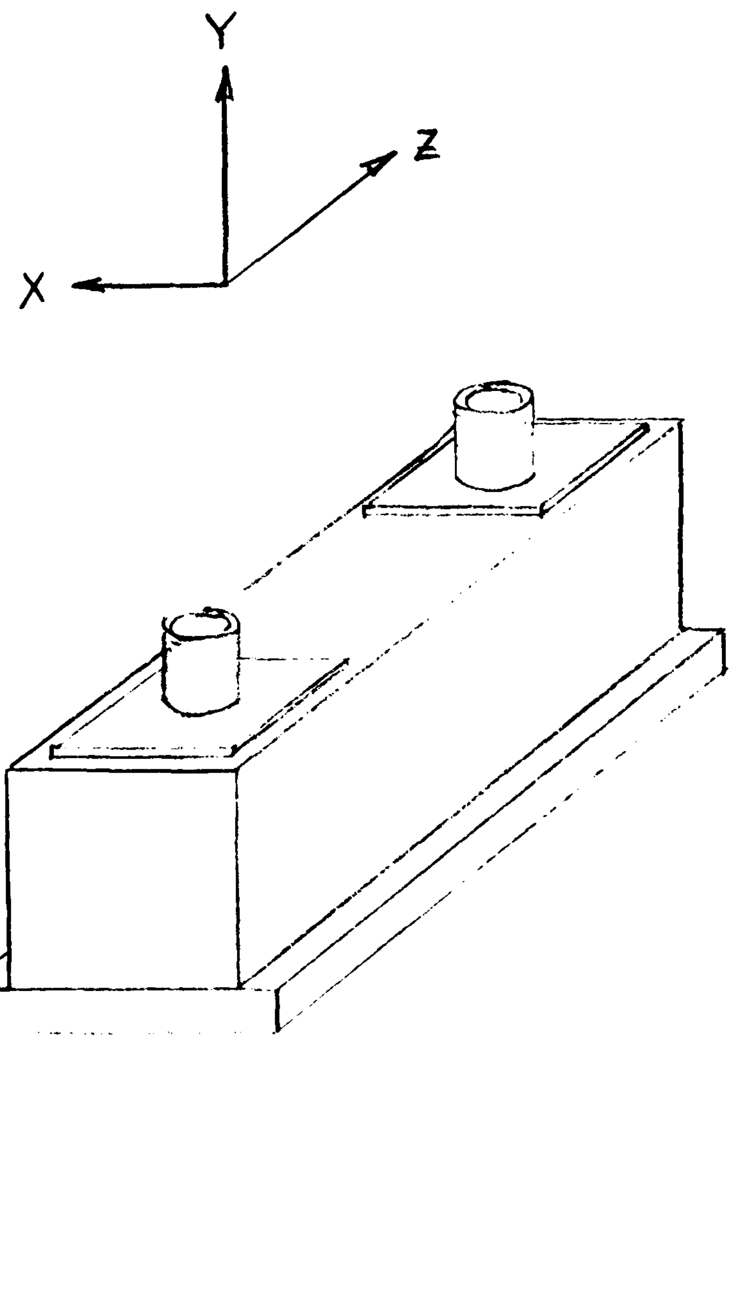
CF12 AMB 40°F 150°F

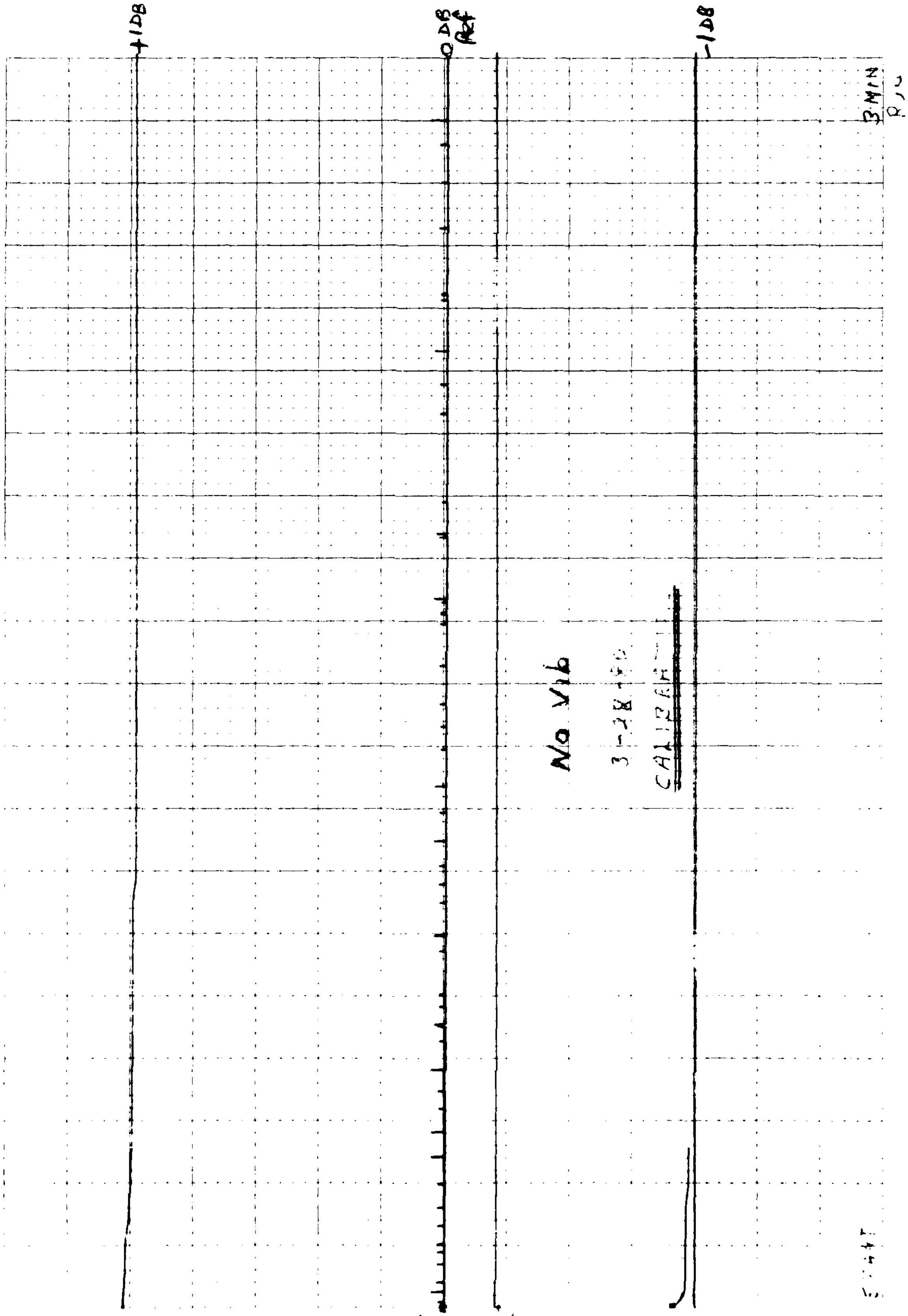
FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	AMB		40°F		150°F	
20.00	33.42	83.44	29.03	85.45	16.37	81.38
25.00	38.23	81.94	30.78	83.82	20.37	84.61
30.00	43.06	95.75	50.17	87.13	25.20	92.92
35.00	47.76	117.05	60.41	95.96	30.70	91.16
40.00	50.99	90.96	66.90	89.19	33.49	84.07
45.00	55.19	90.30	63.50	100.89	35.80	96.46
50.00	60.46	86.14	59.06	93.69	33.63	85.20

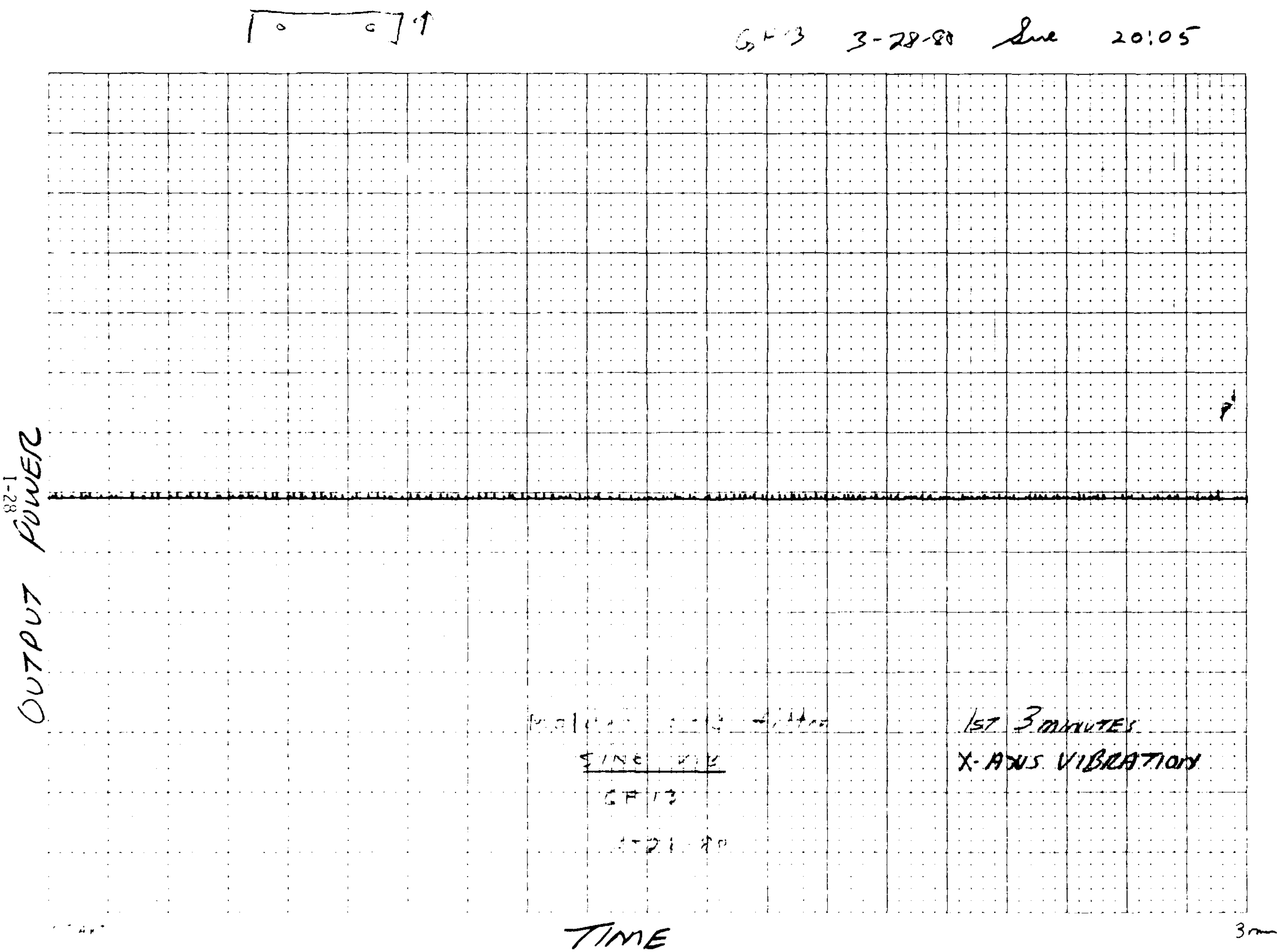
ANNEX B

VIBRATION TEST DATA

VIBRATION AXIS

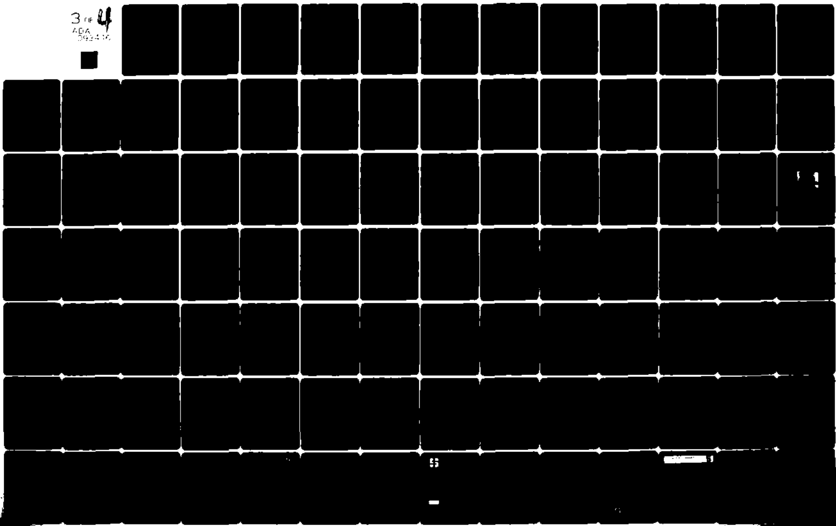


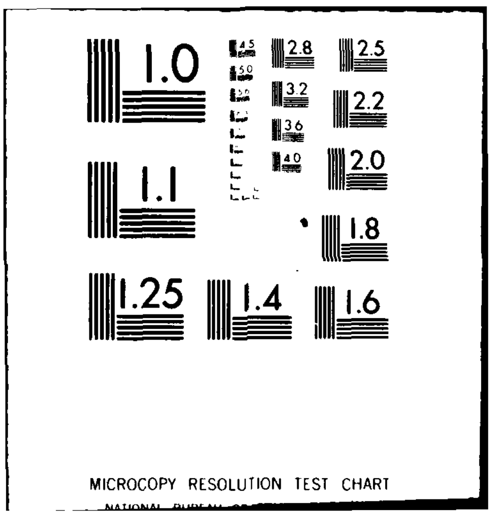

+1DB
0 DB
Ref
-1DB
3 MIN
No Vib

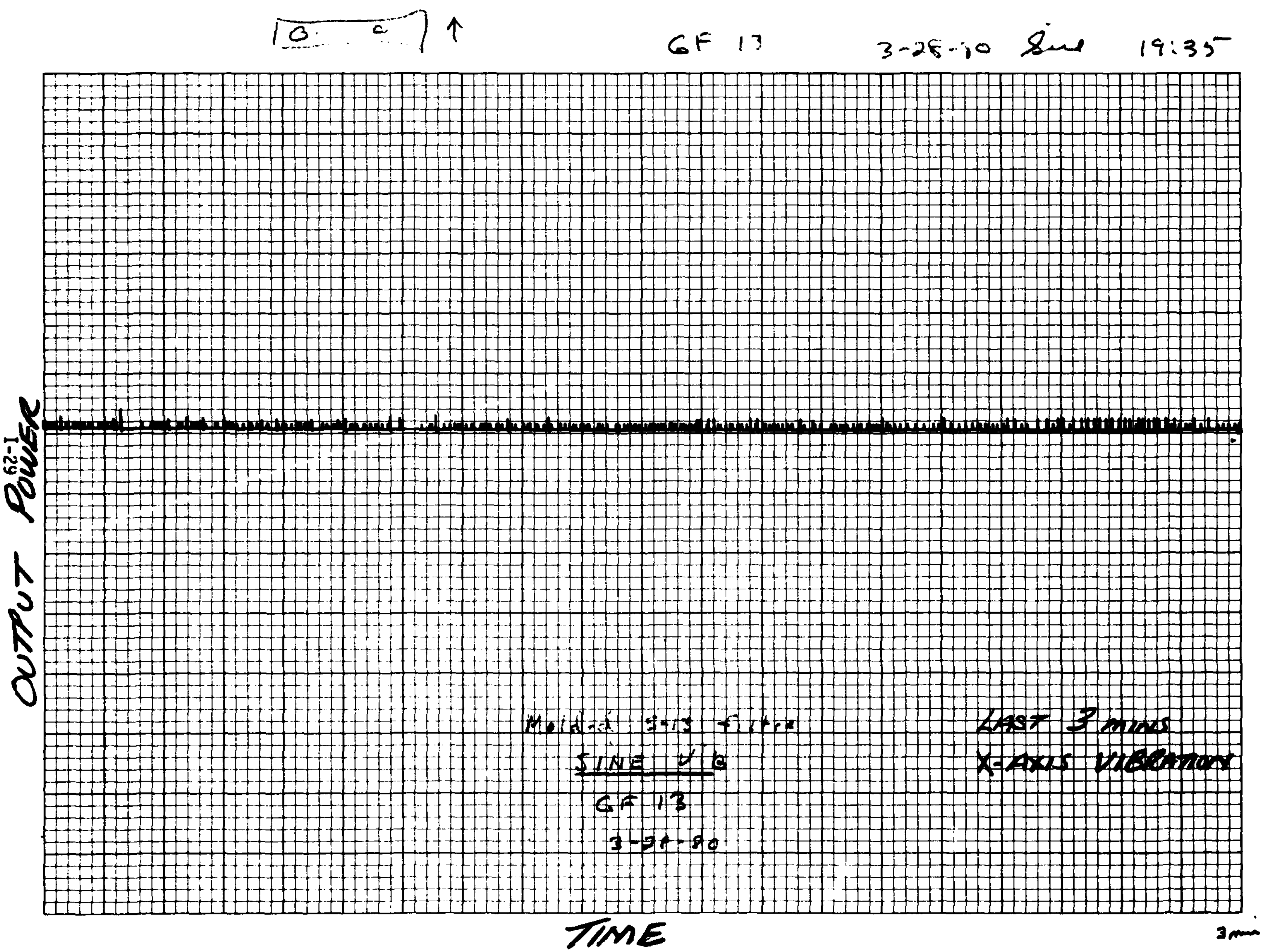

GF-3 3-28-80 20:05
1st 3 MINUTES
X-AXIS VIBRATION
OUTPUT POWER
TIME
3m

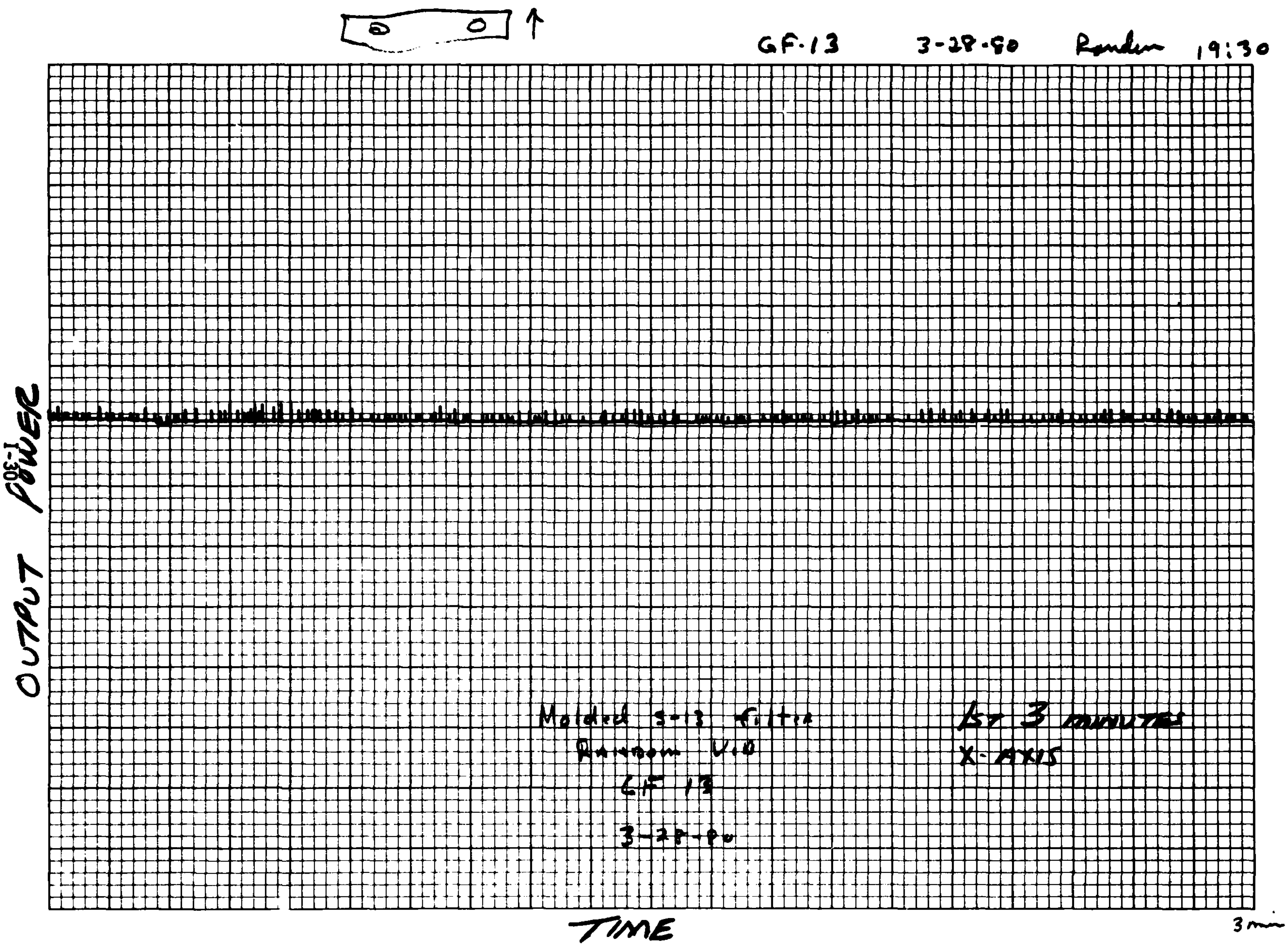
AD-A093 446 GENERAL DYNAMICS CORP POMONA CA POMONA DIV F/G 13/8
MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS.(U)
APR 80 W L MACTURK N66001-79-C-0022
UNCLASSIFIED NAVSEA-MT-S-617-78 NL

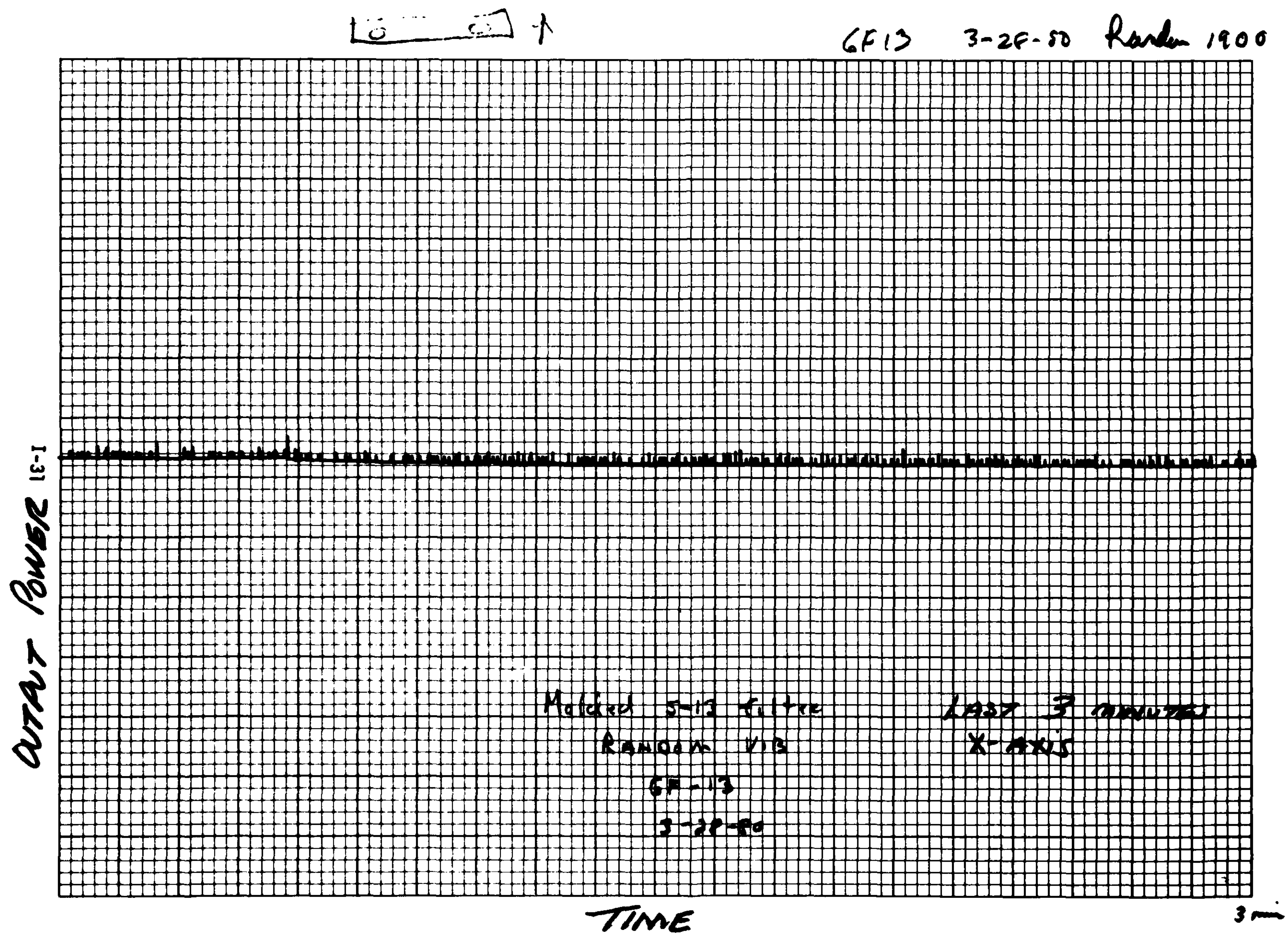
3 of 4
ADA
093446

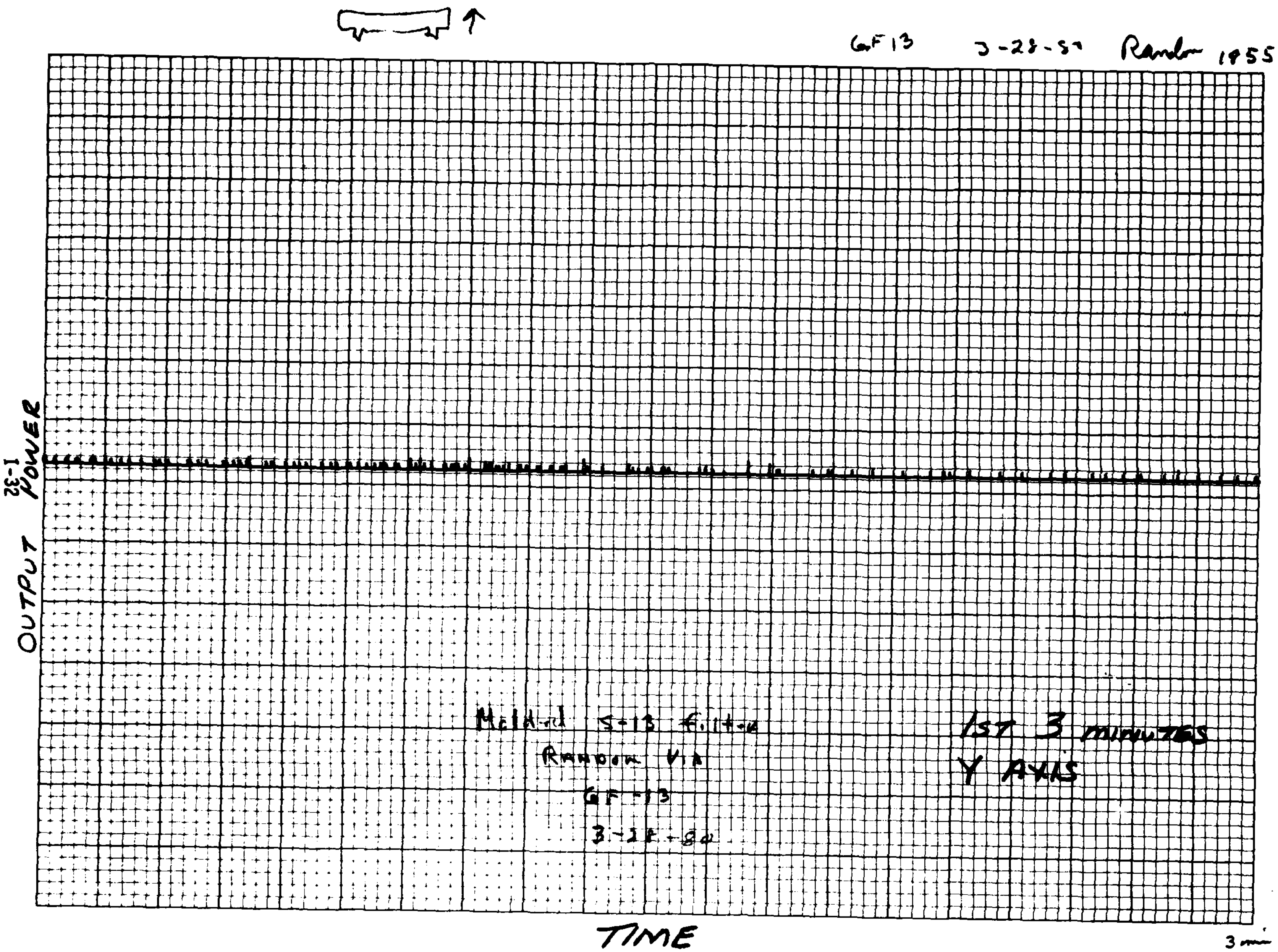



1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART


GF 13
19:35
OUTPUT POWER
LAST 3 MINS
X-AXIS VIBRATION
SINE
GF 13
TIME

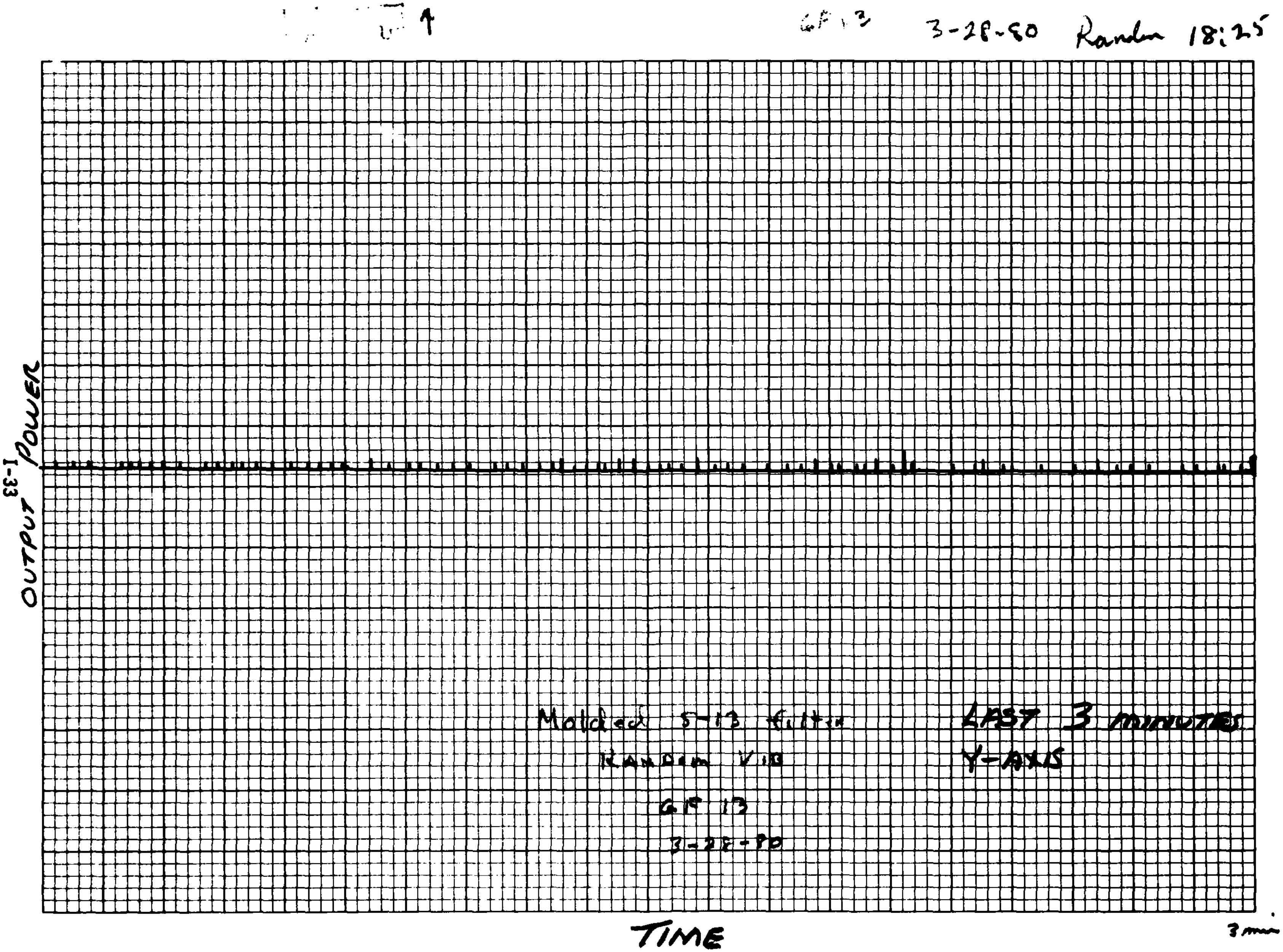

GF-13
3-28-80
Random
19:30
OUTPUT POWER
TIME
3 min
Molded 5-13 filter
Random Vib
GF 13
3-28-80
1st 3 MINUTES
X-AXIS

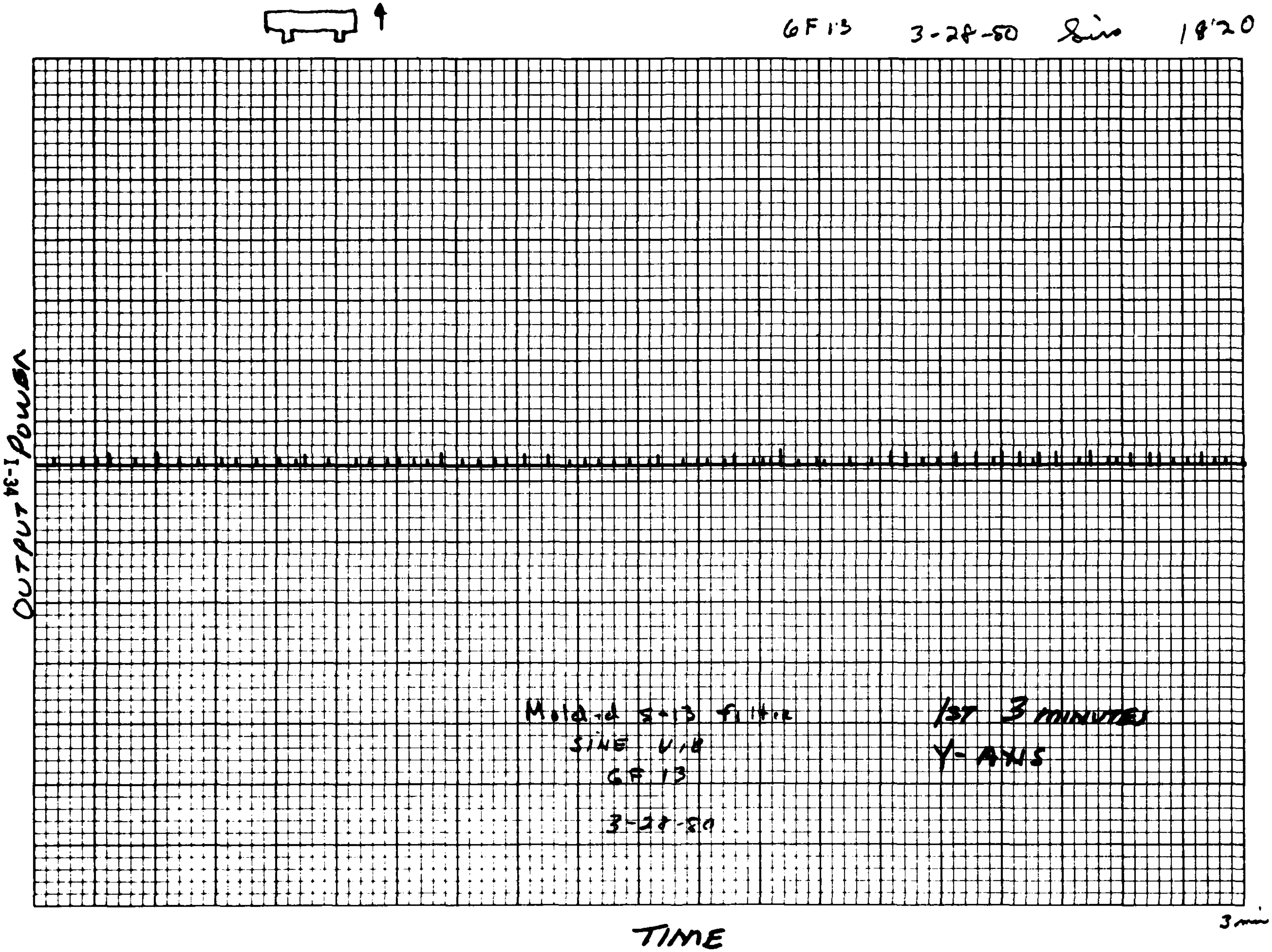

6F13 3-28-80 Random 1900
OUTPUT POWER
TIME
3 min
Matched 5-13 filter
Random VIB
6F-13
3-28-80
LAST 3 MINUTES
X-AXIS

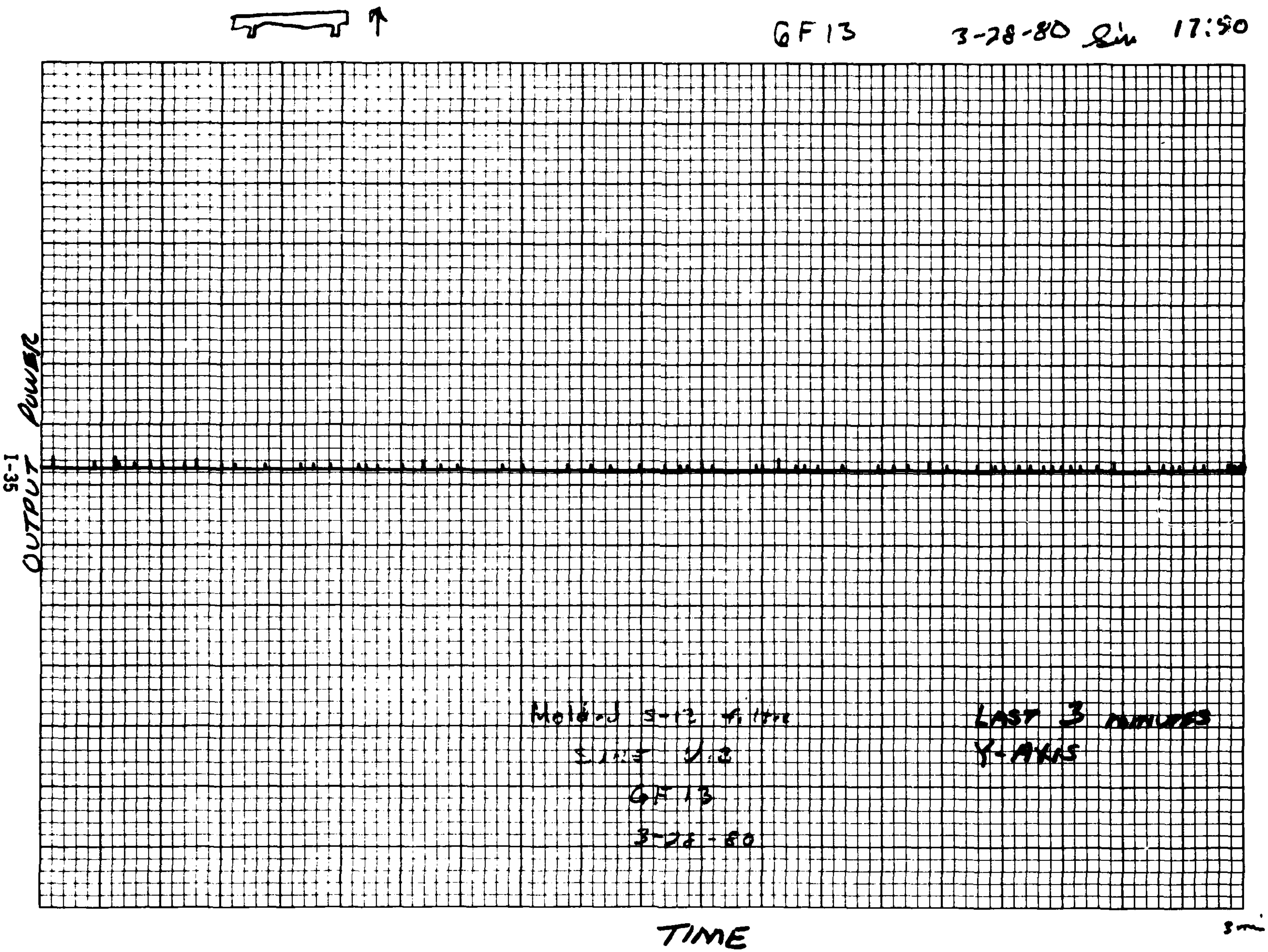

GF 13
3-28-57
Random 1955
OUTPUT POWER
TIME
3 min
Mcldrd S-13 Filter
Random V.A
GF-13
3-28-80
1st 3 minutes
Y AXIS

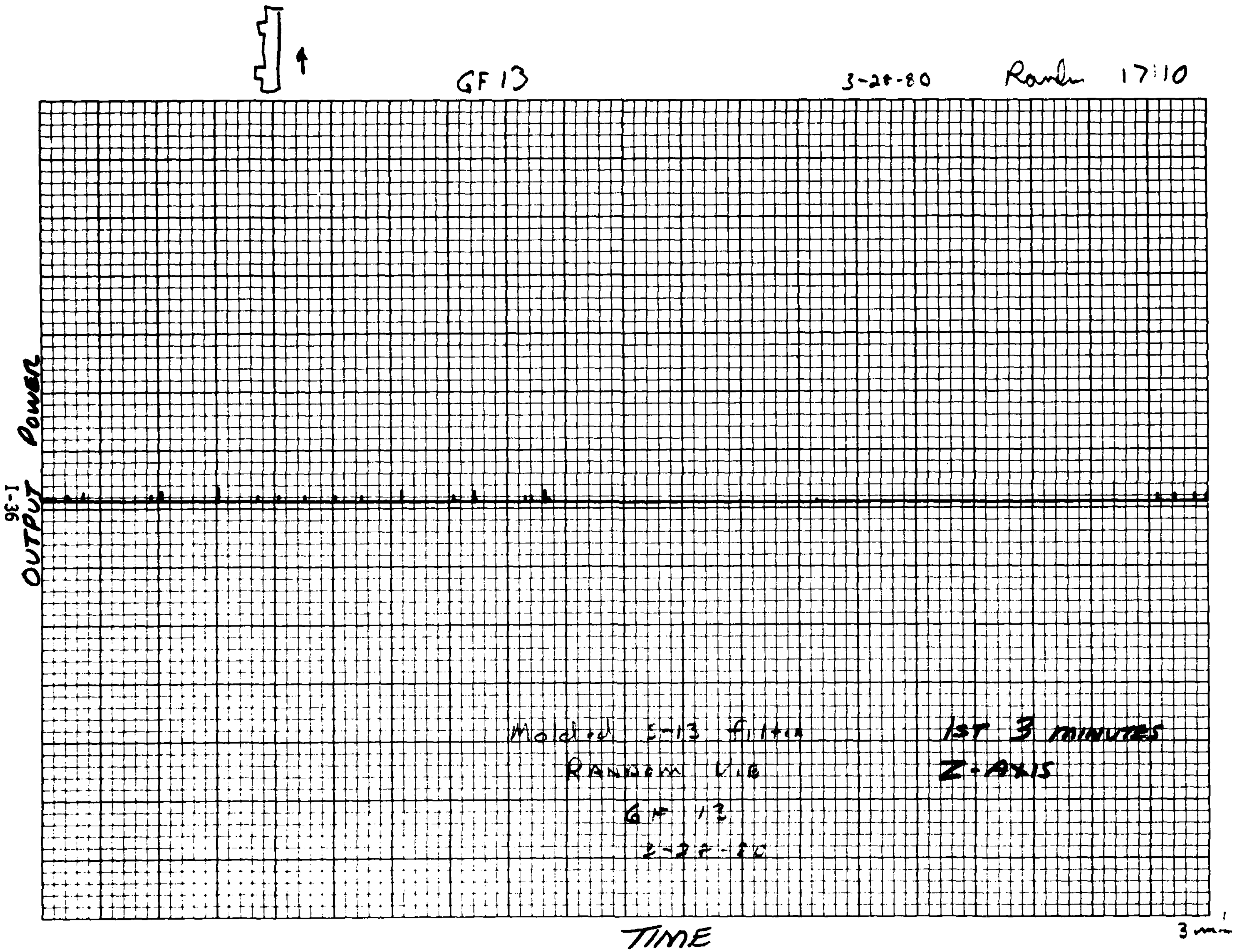
K•E 5 X 5 TO 1/2 INCH • 7 X 10 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

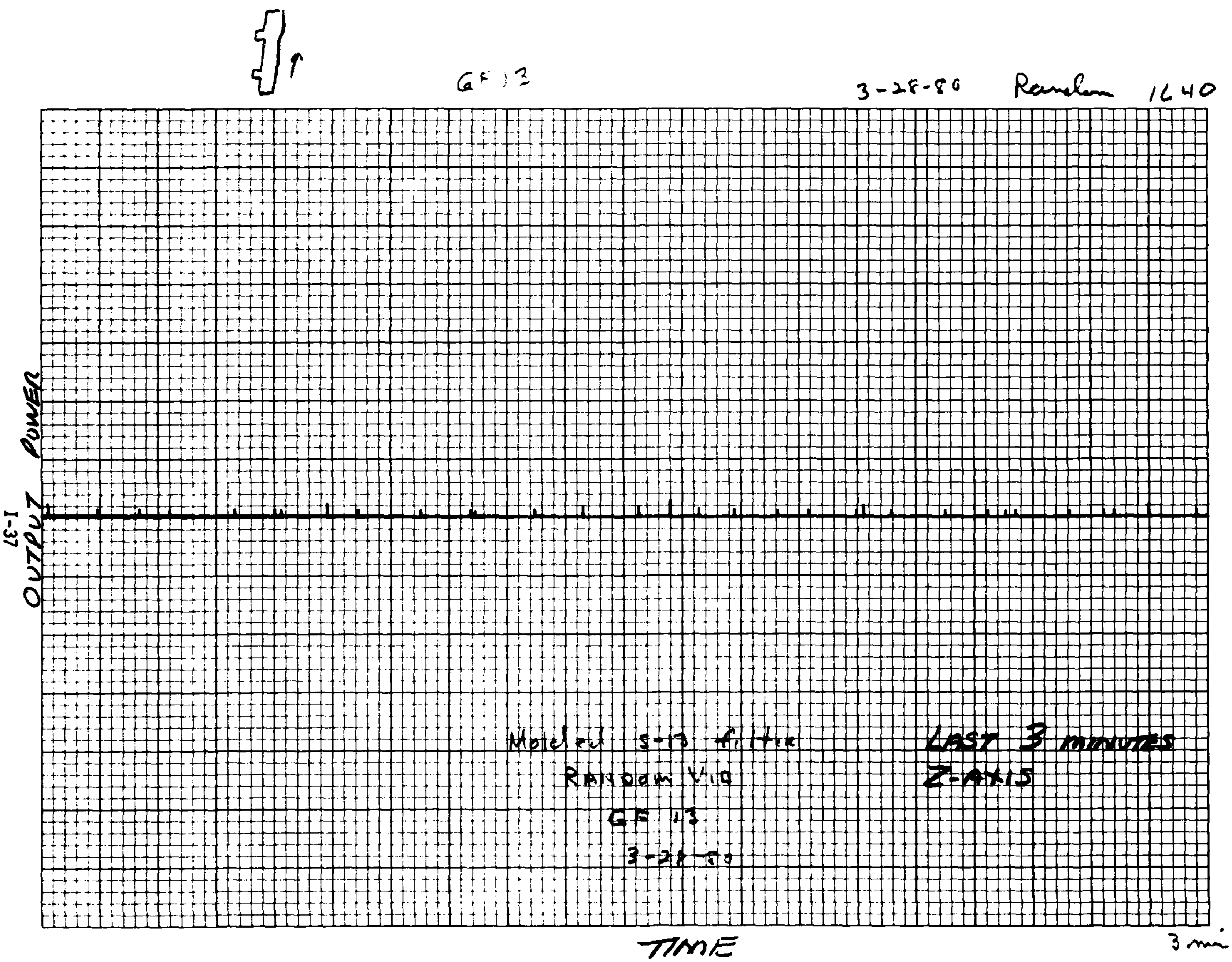
46 0863

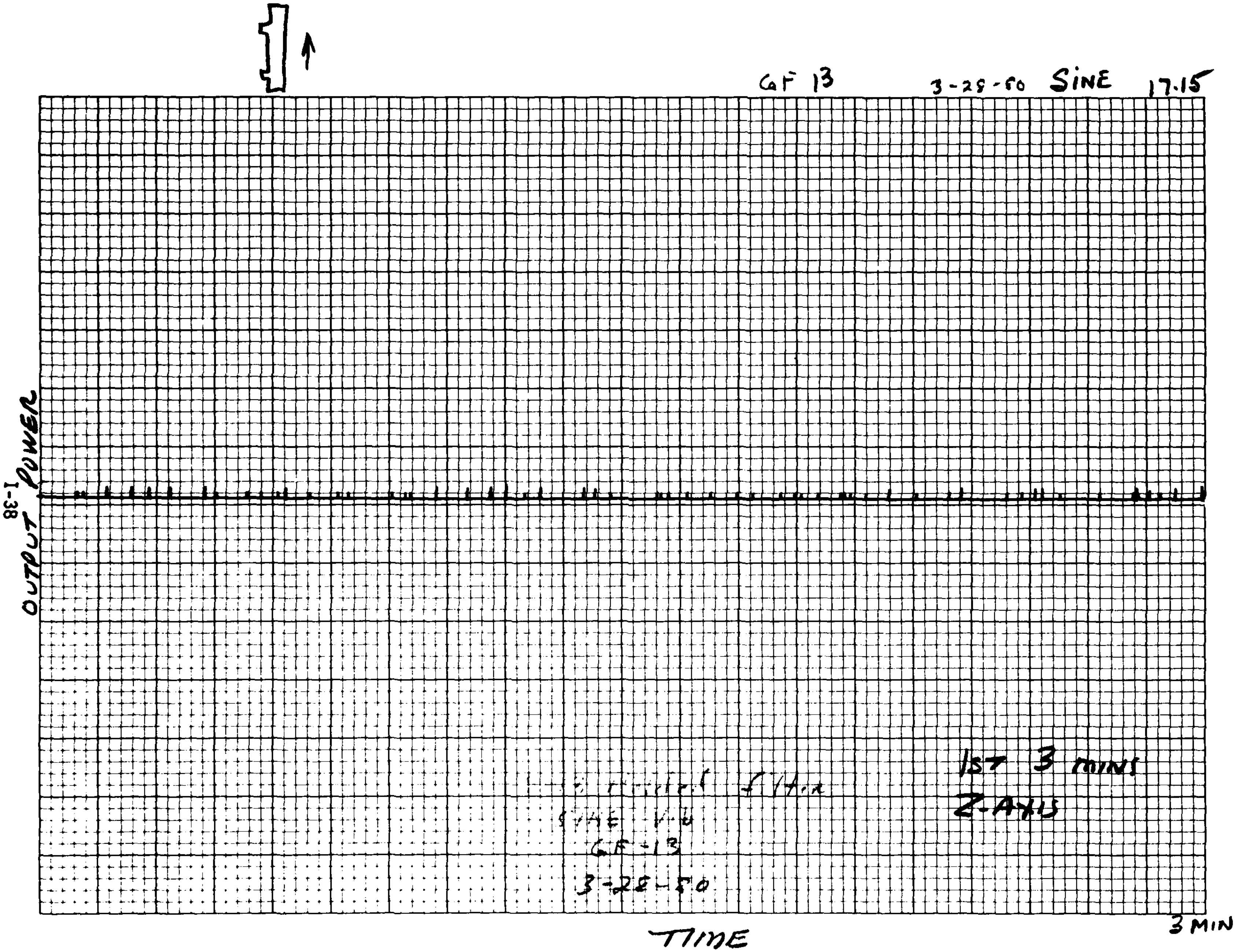


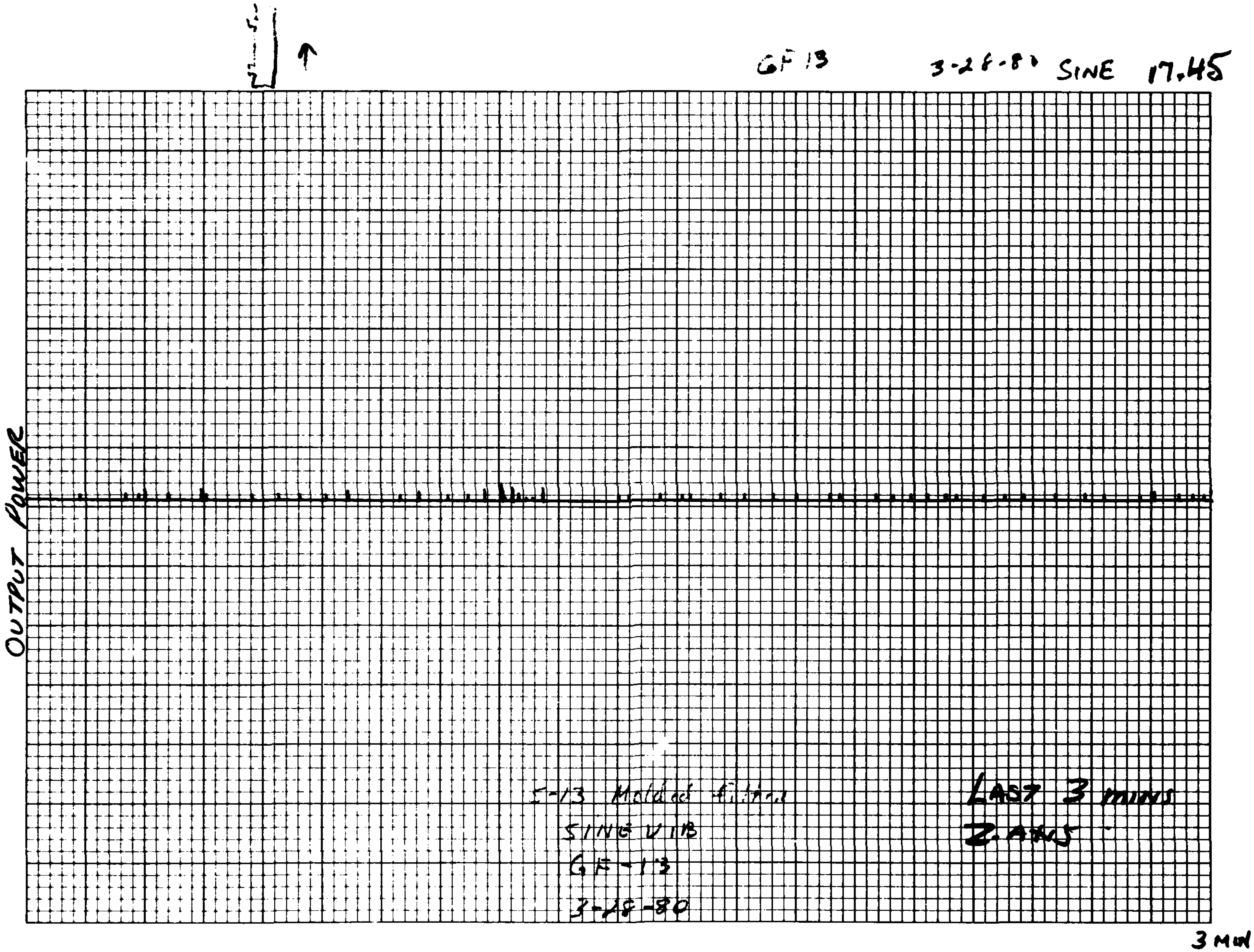

GF 13 3-28-80 Sine 18'20
OUTPUT POWER
TIME
3 min
Molded S-13 filter
SINE VIB
GF 13
3-28-80
1st 3 MINUTES
Y-AXIS

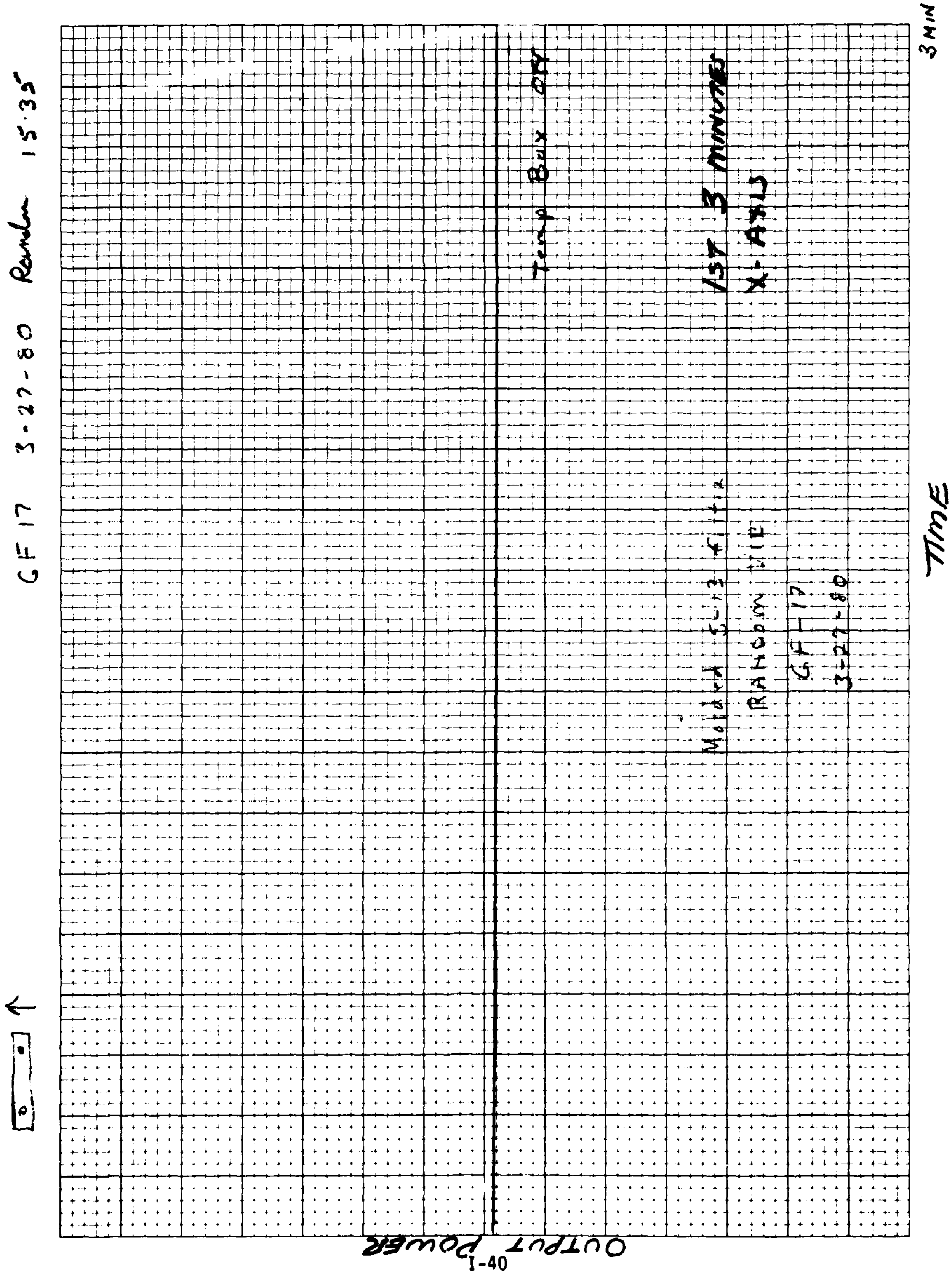

GF 13
3-28-80
17:50
OUTPUT POWER
LAST 3 MINUTES
Y-AXIS
GF 13
3-28-80
TIME
3 min


GF 13
Random 17:10
Molded E-13 Filter
Random Vib
1st 3 minutes
Z-AXIS
OUTPUT POWER
TIME
3 min

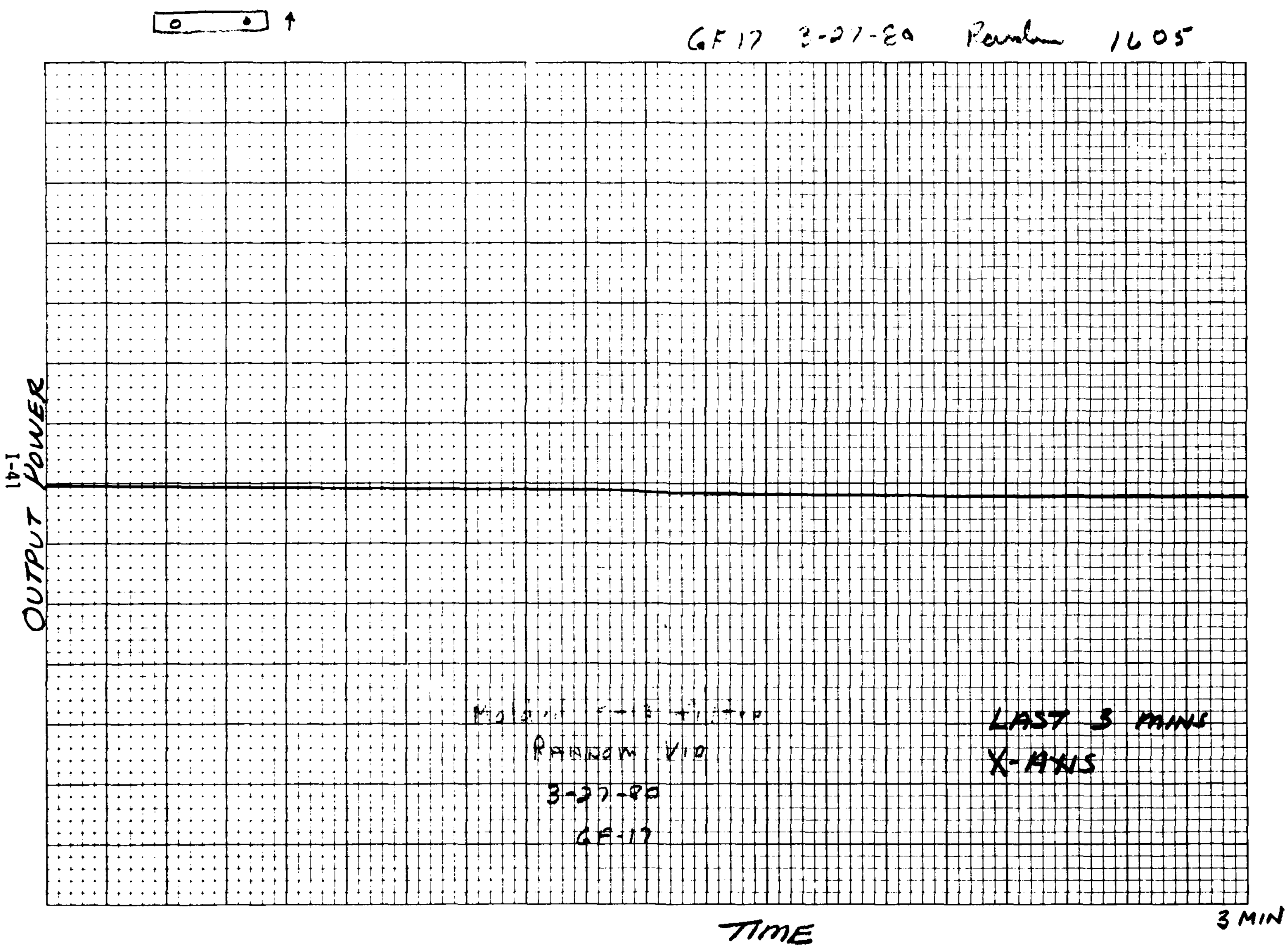

GF 13
3-28-80 Random 1640
OUTPUT POWER
Molded S-13 filter
Random Vib
GF 13
3-28-80
LAST 3 MINUTES
Z-AXIS
TIME
3 min

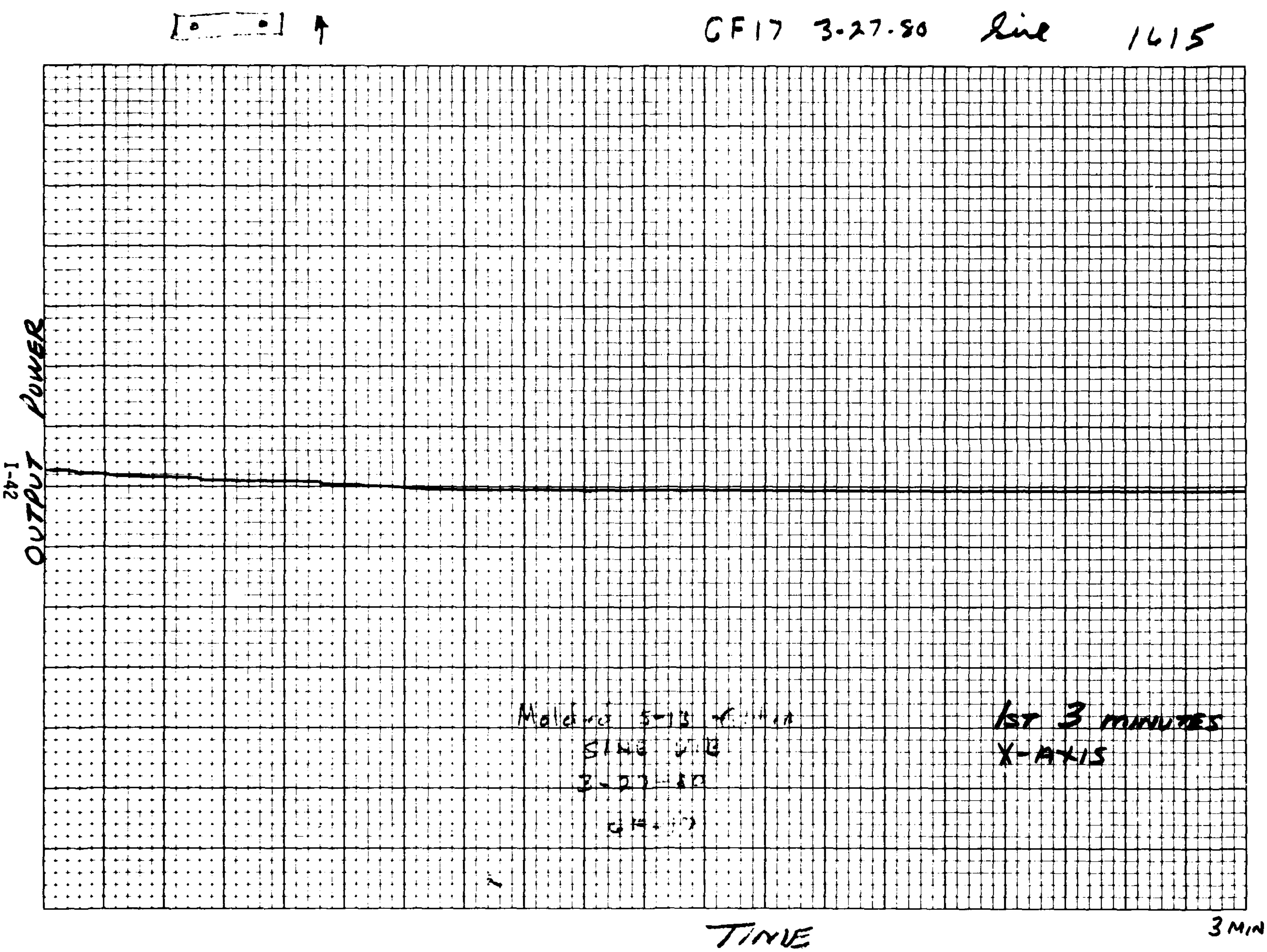

GF 13
3-28-80 SINE 17.15
OUTPUT POWER
1st 3 MINS
Z-AXIS
GF-13
3-28-80
TIME
3 MIN

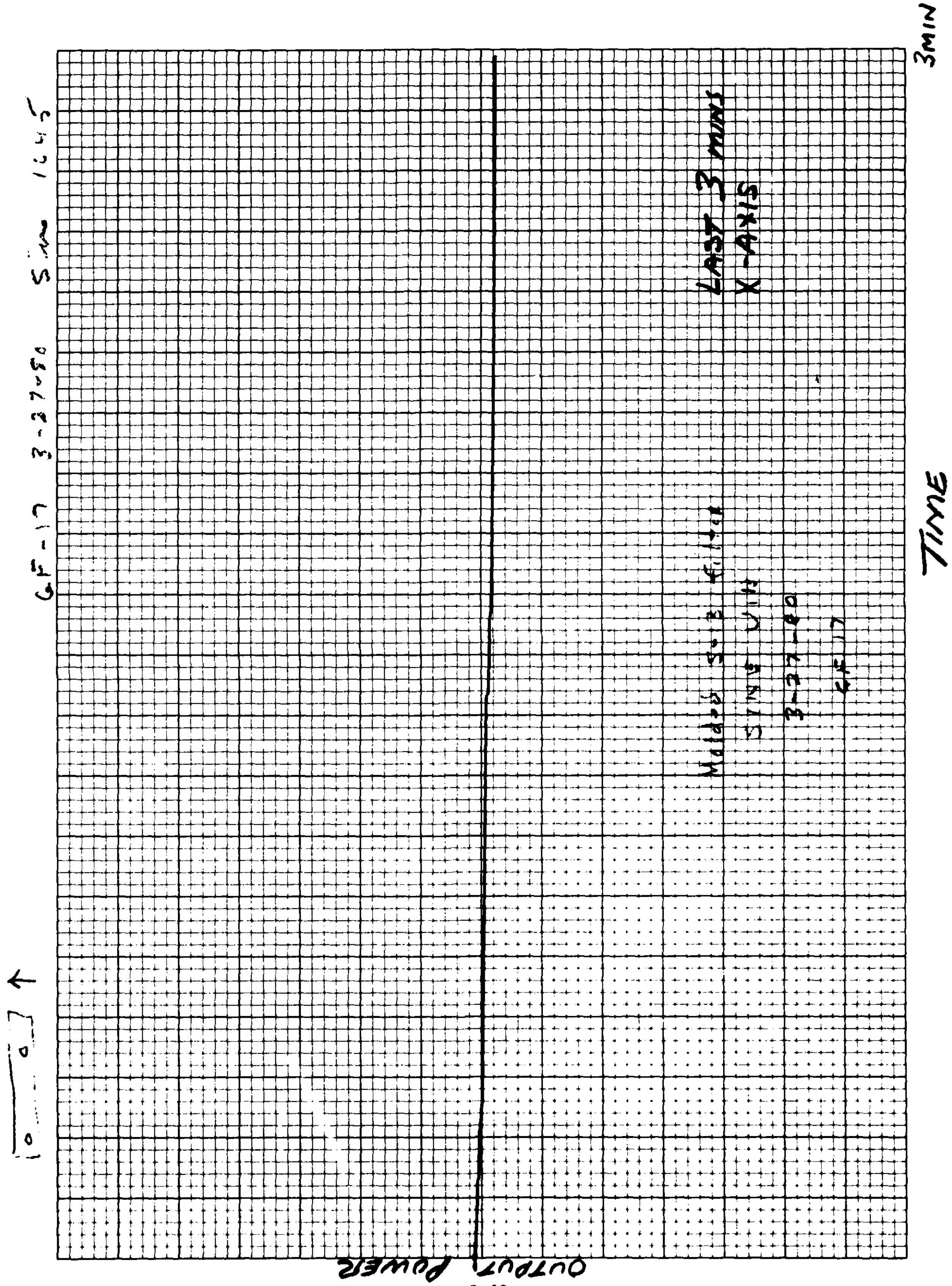

GF 13
SINE 17.45
OUTPUT POWER
LAST 3 MINS
SINE V1B
GF-13
3-28-80
3 MIN



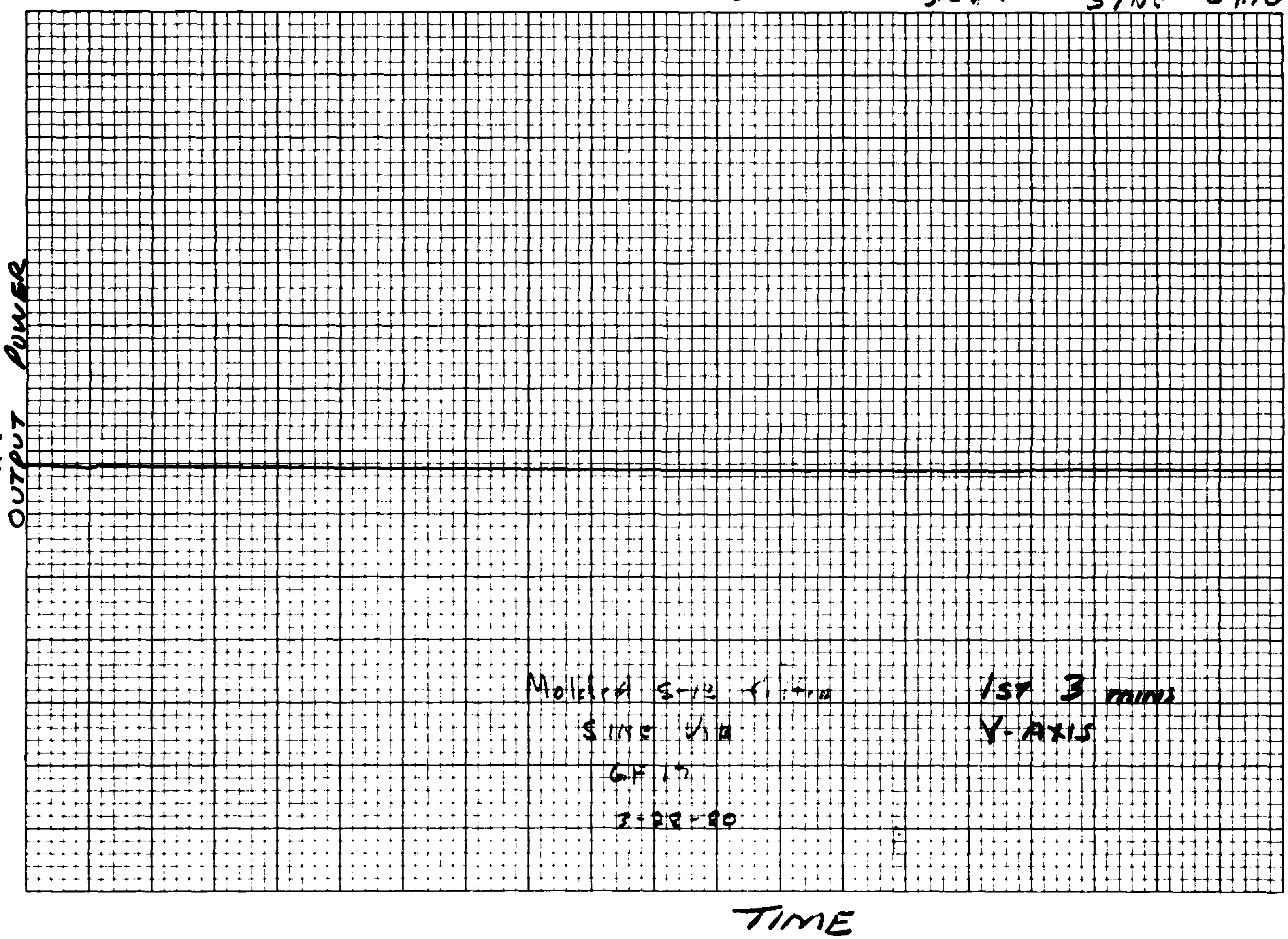
GF 17 3-27-80 Random 15:35
Temp Box OFF
1ST 3 MINUTES
X-AXIS
Molded 5-13 filter
RANDOM VIB
GF-17
3-27-80
TIME
3 MIN
OUTPUT POWER

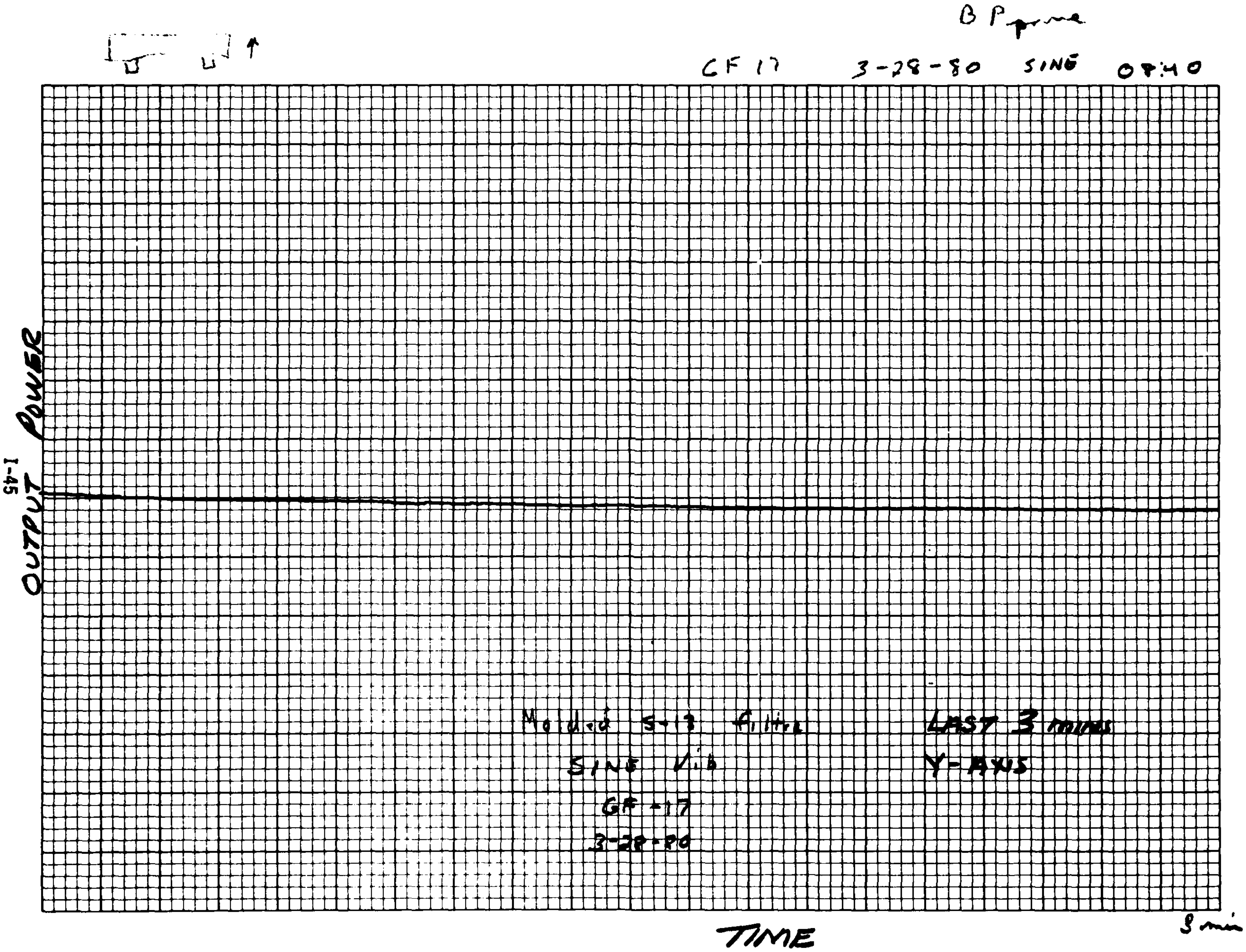

GF 17 3-27-80 Random 1605
OUTPUT POWER
TIME
3 MIN
LAST 3 MINS
X-AXIS
RANDOM VIB
3-27-80
GF-17

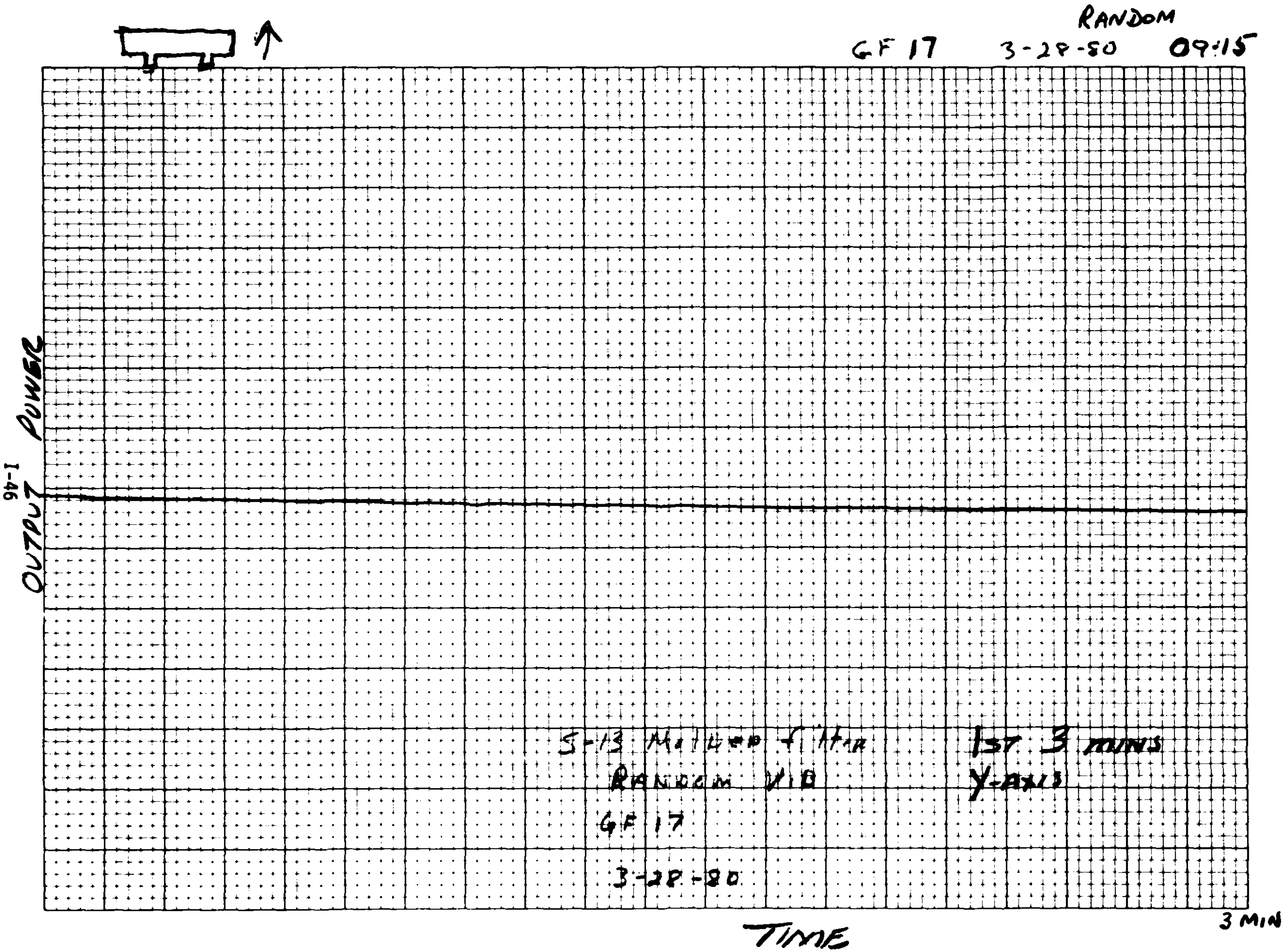

CF17 3-27-80 line 1615
OUTPUT POWER
TIME
3 MIN
1st 3 MINUTES
X-AXIS

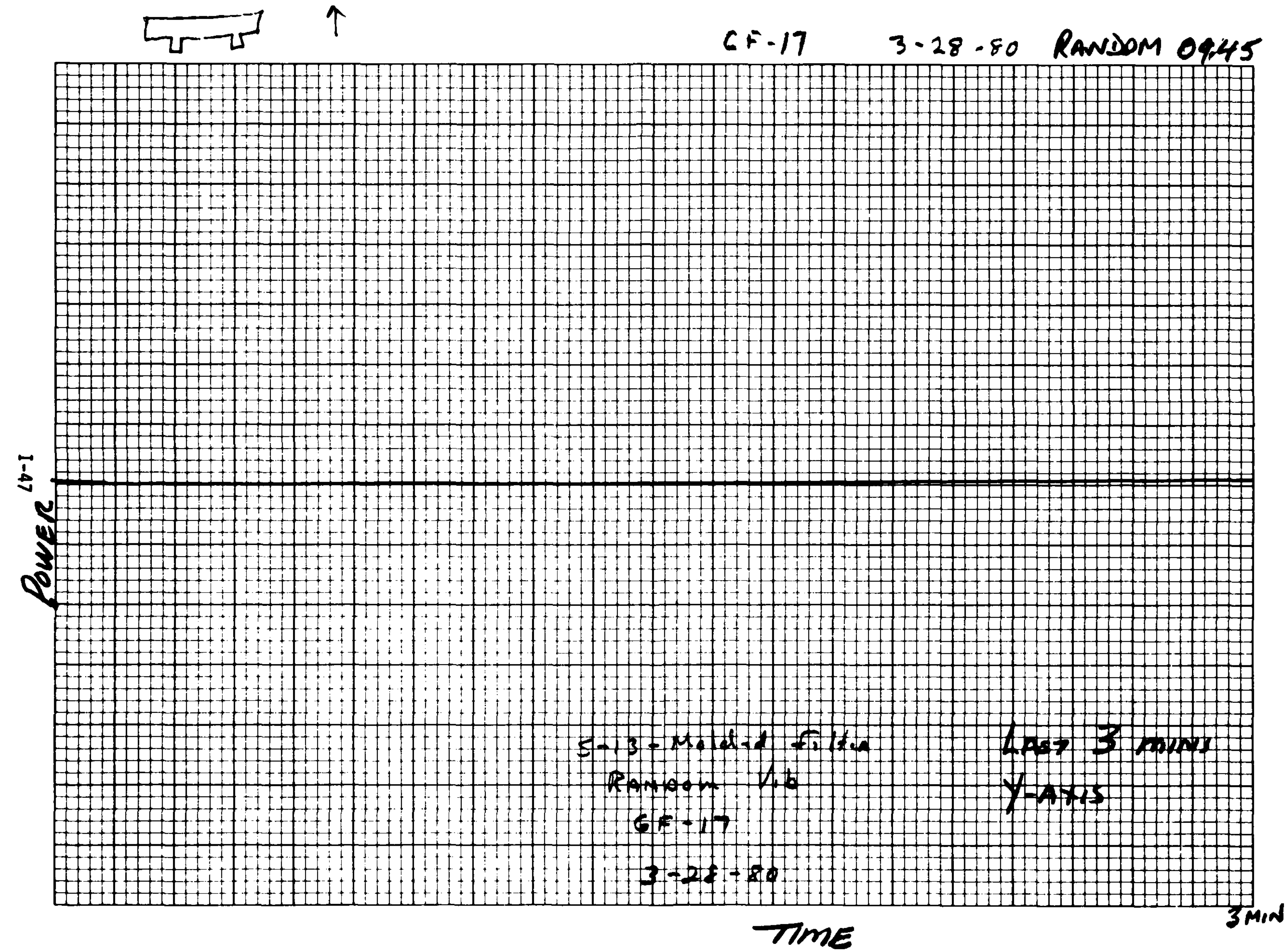

3MIN
LAST 3 MINS
X-AXIS
TIME
OUTPUT POWER

GF 17 3/28/80 SINE 09.10

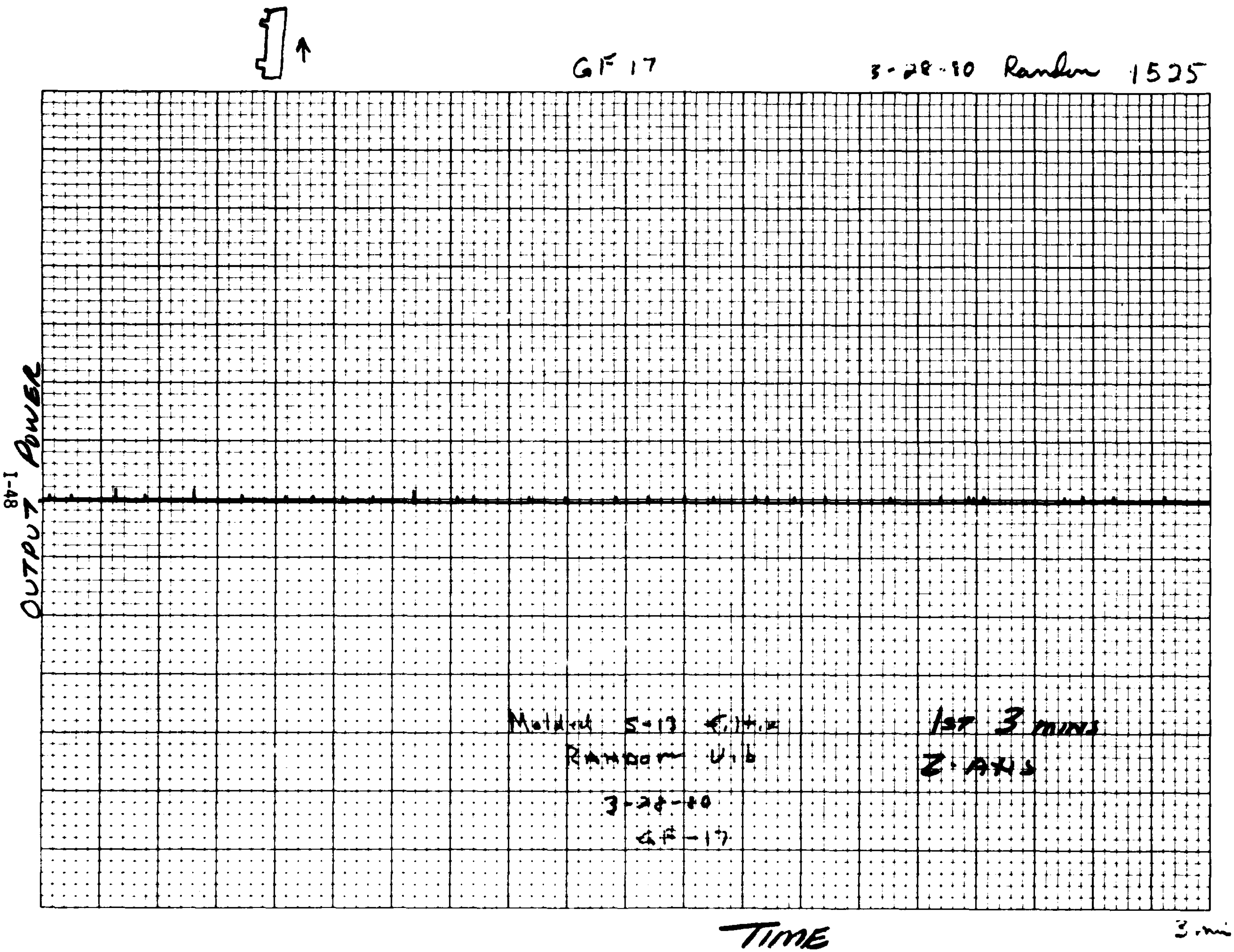


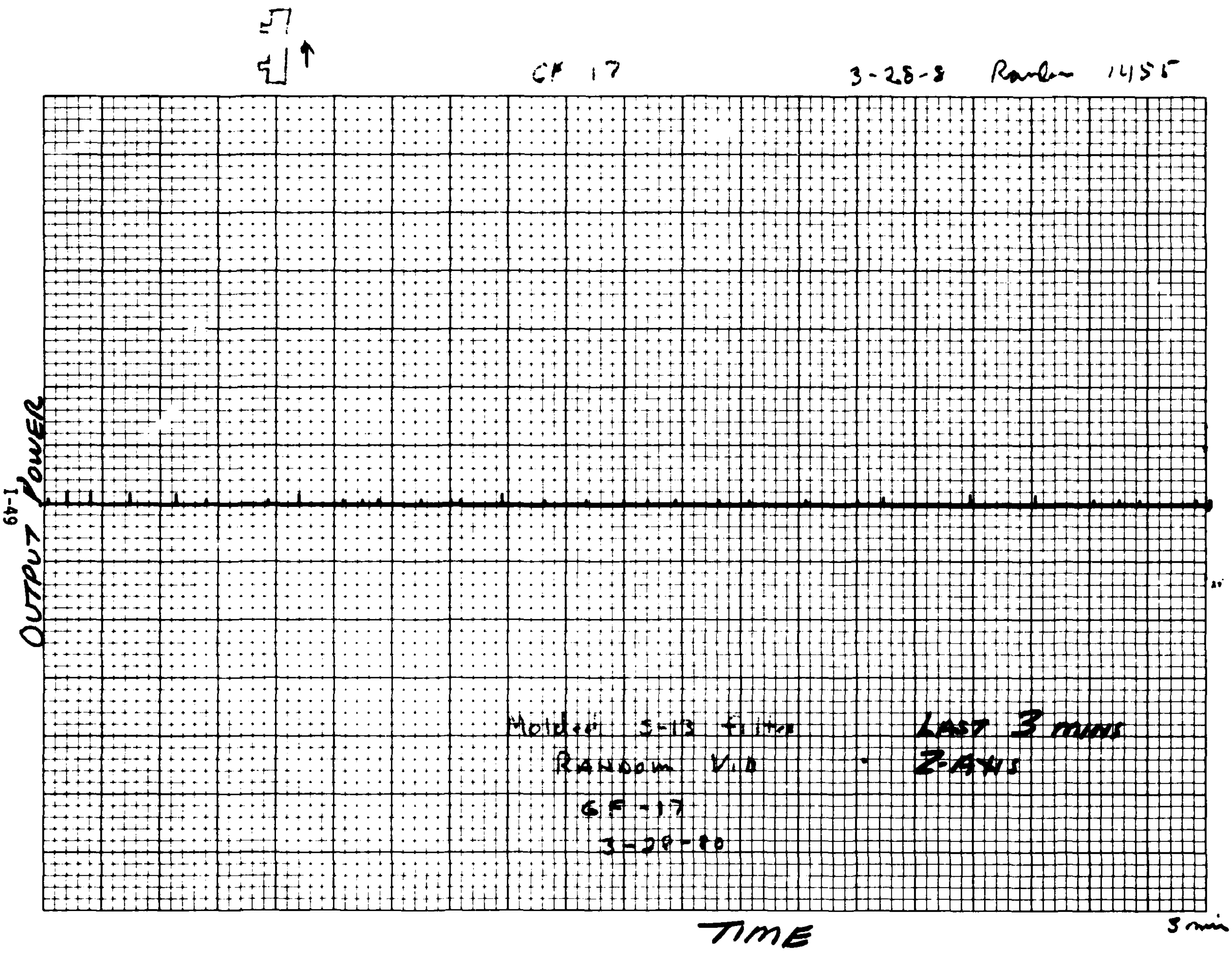

B P prime
CF 17 3-28-80 SINE 08:40
OUTPUT POWER
Molded S-13 filter
SINE Vib
GF-17
3-28-80
LAST 3 mins
Y-AXIS
TIME
3 min


RANDOM
GF 17 3-28-80 09:15
5-13 Milled & Hair
RANDOM VIB
GF 17
3-28-80
1st 3 mins
Y-AXIS
OUTPUT POWER
TIME
3 MIN

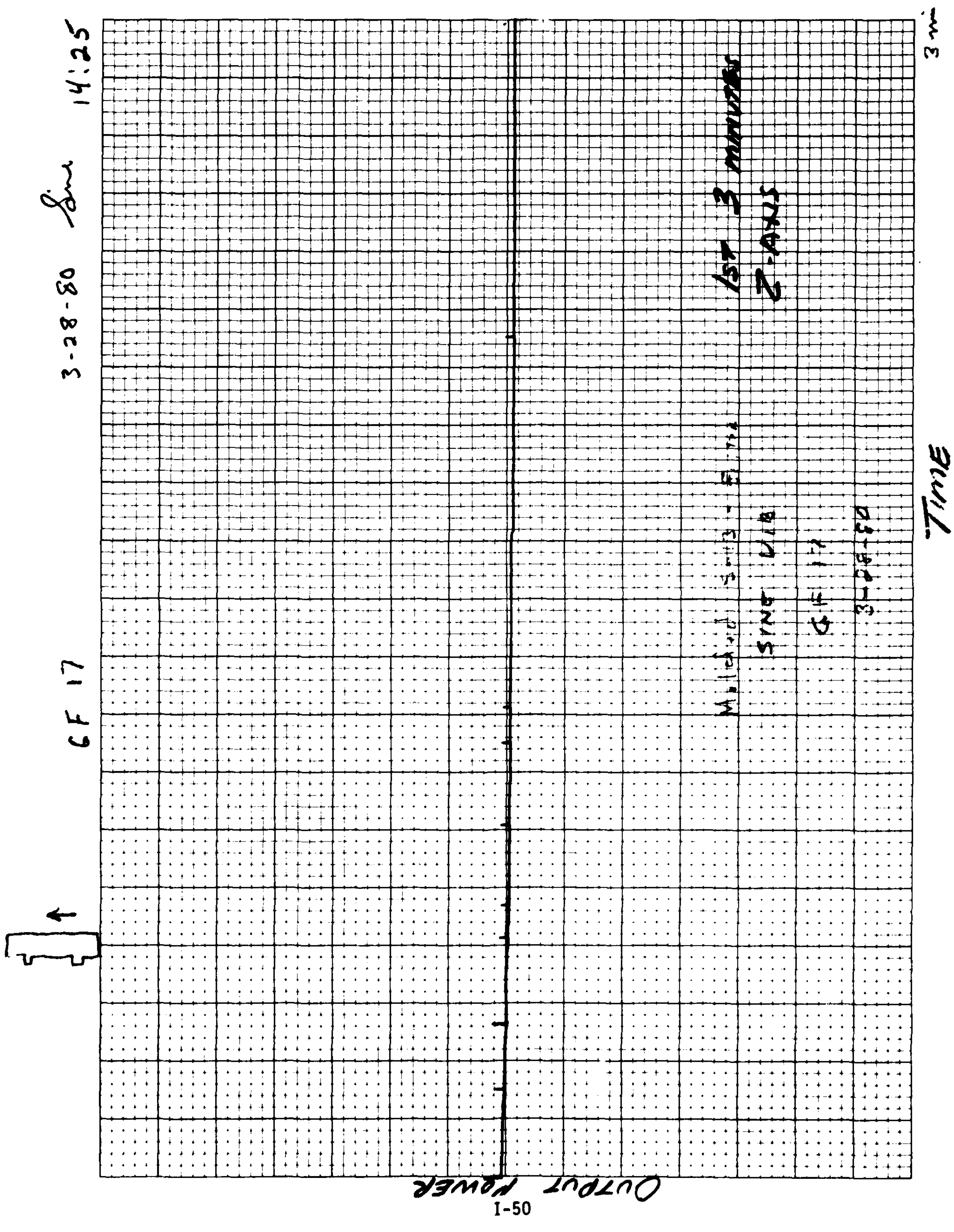


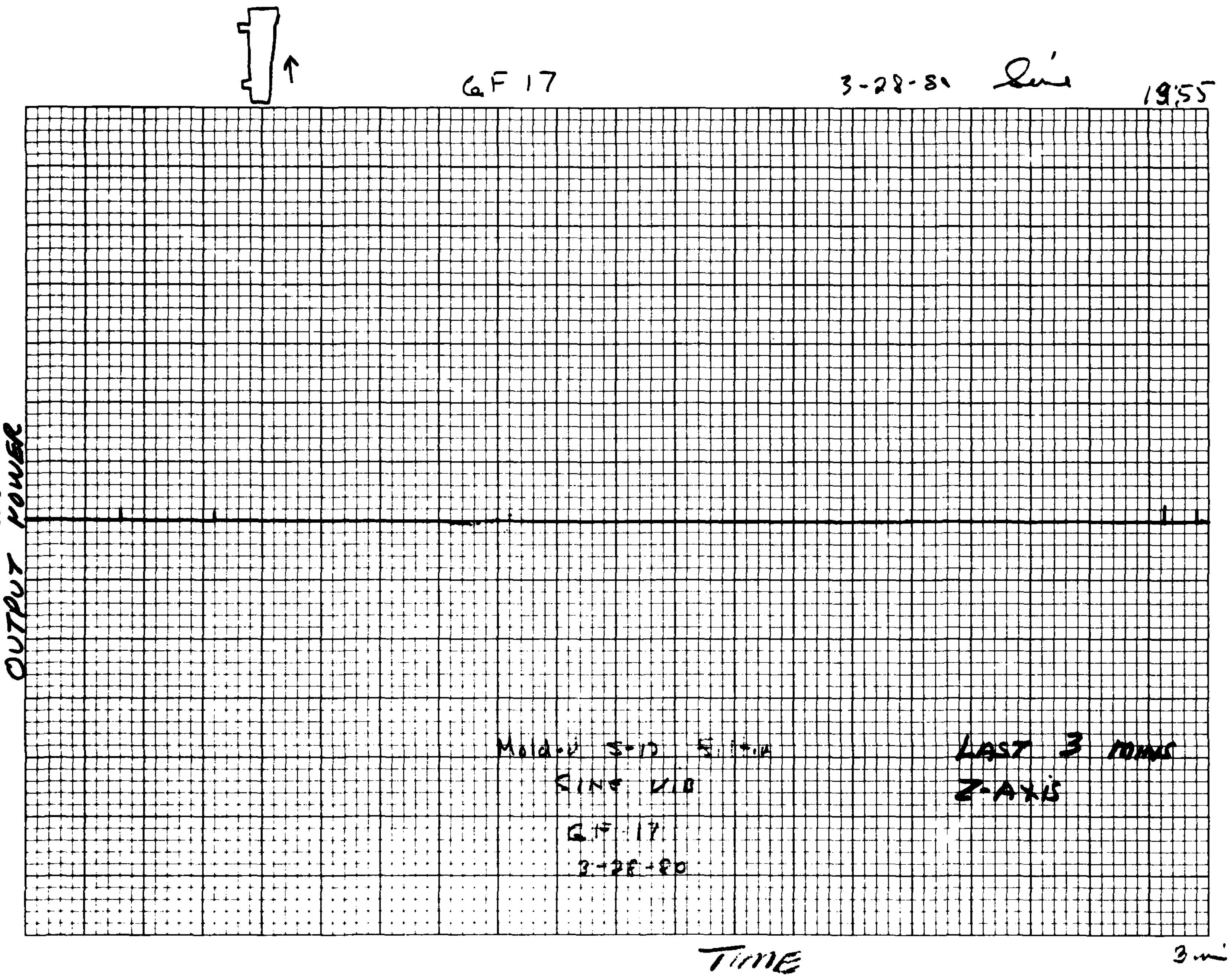
GF-17
3-28-80
RANDOM 09:45
POWER
5-13-Molded Filter
Random Vib
GF-17
3-28-80
LAST 3 MINS
Y-AXIS
TIME
3MIN

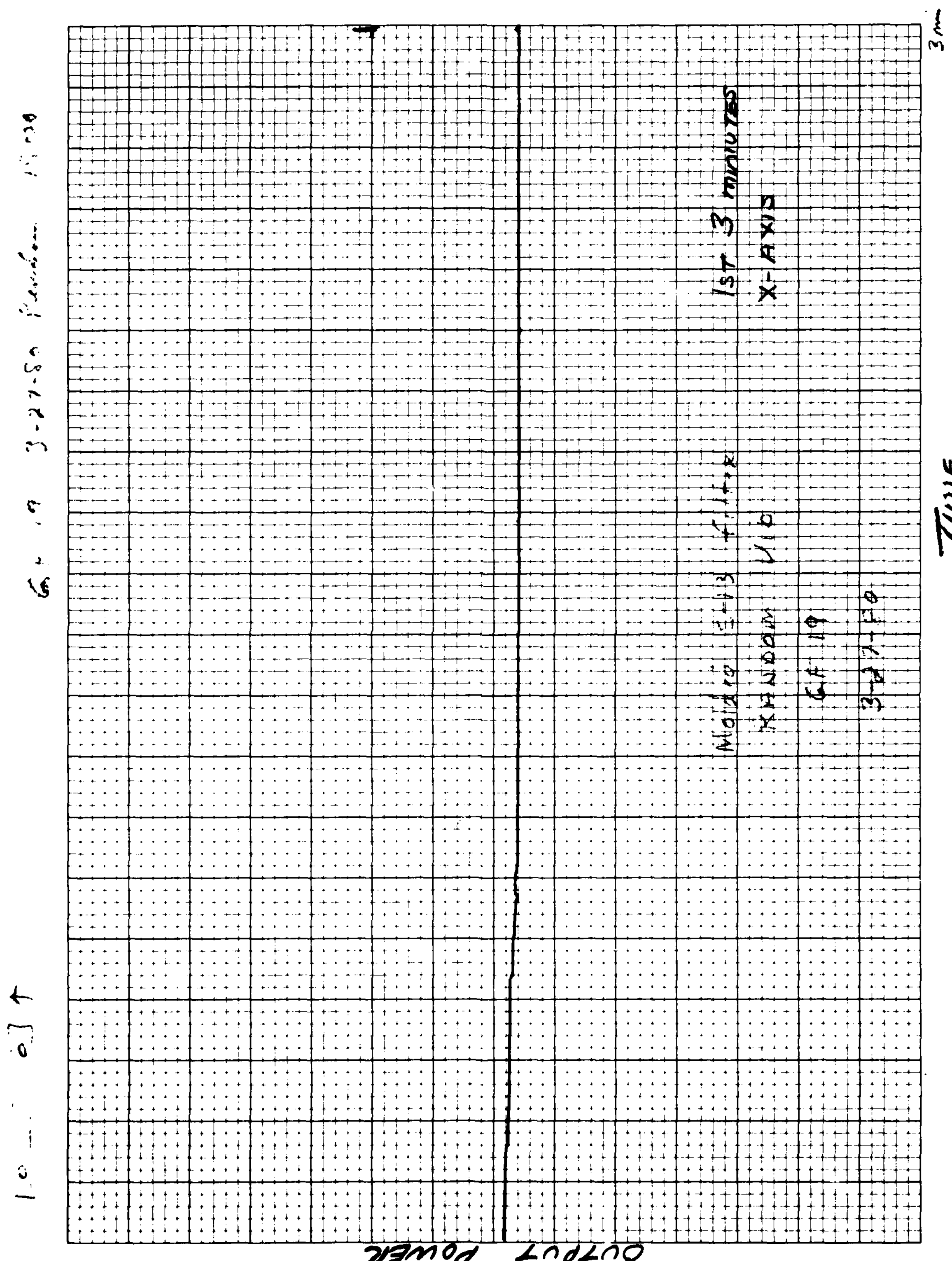

GF 17
OUTPUT POWER
TIME
Random Vib
3-28-80
GF-17
1st 3 mins
Z AXIS

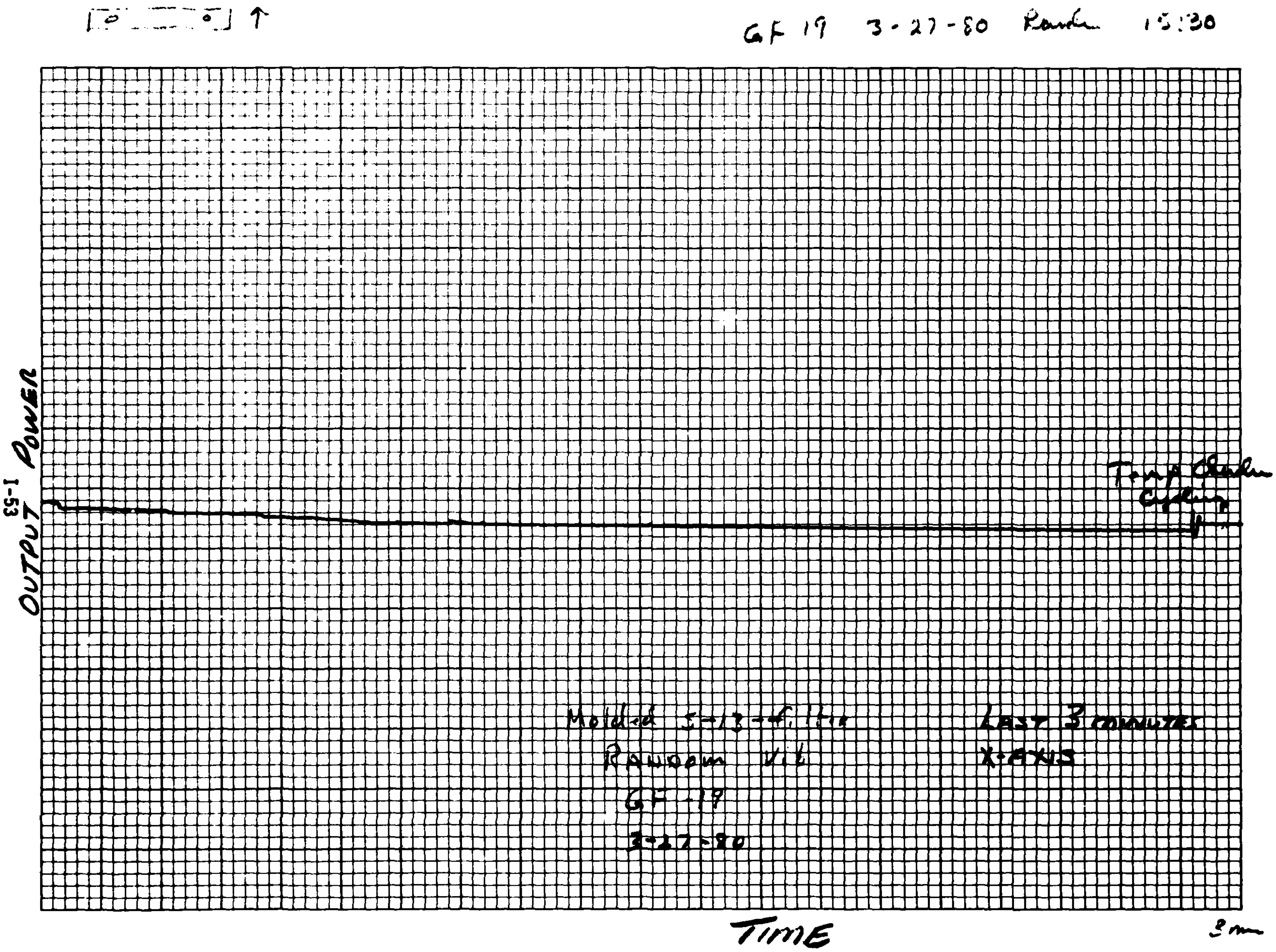


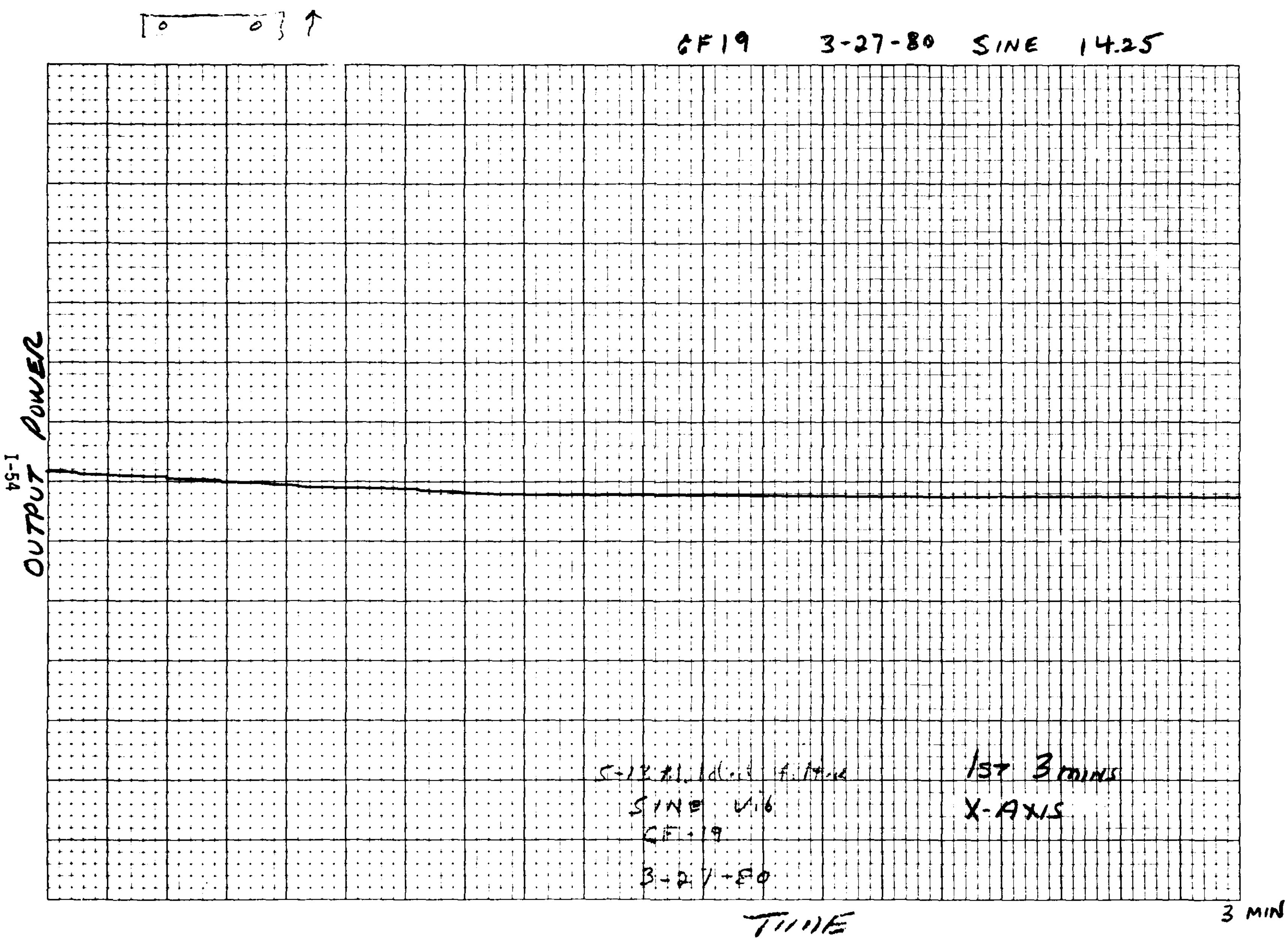
CF 17
3-28-8
OUTPUT POWER
TIME
3 min
RANDOM VIB
GF-17
3-28-80
LAST 3 MINS
Z-AXIS


3-28-80
14:25
GF 17
1st 3 MINUTES
Z-AXIS
SINE VIB
TIME
OUTPUT POWER

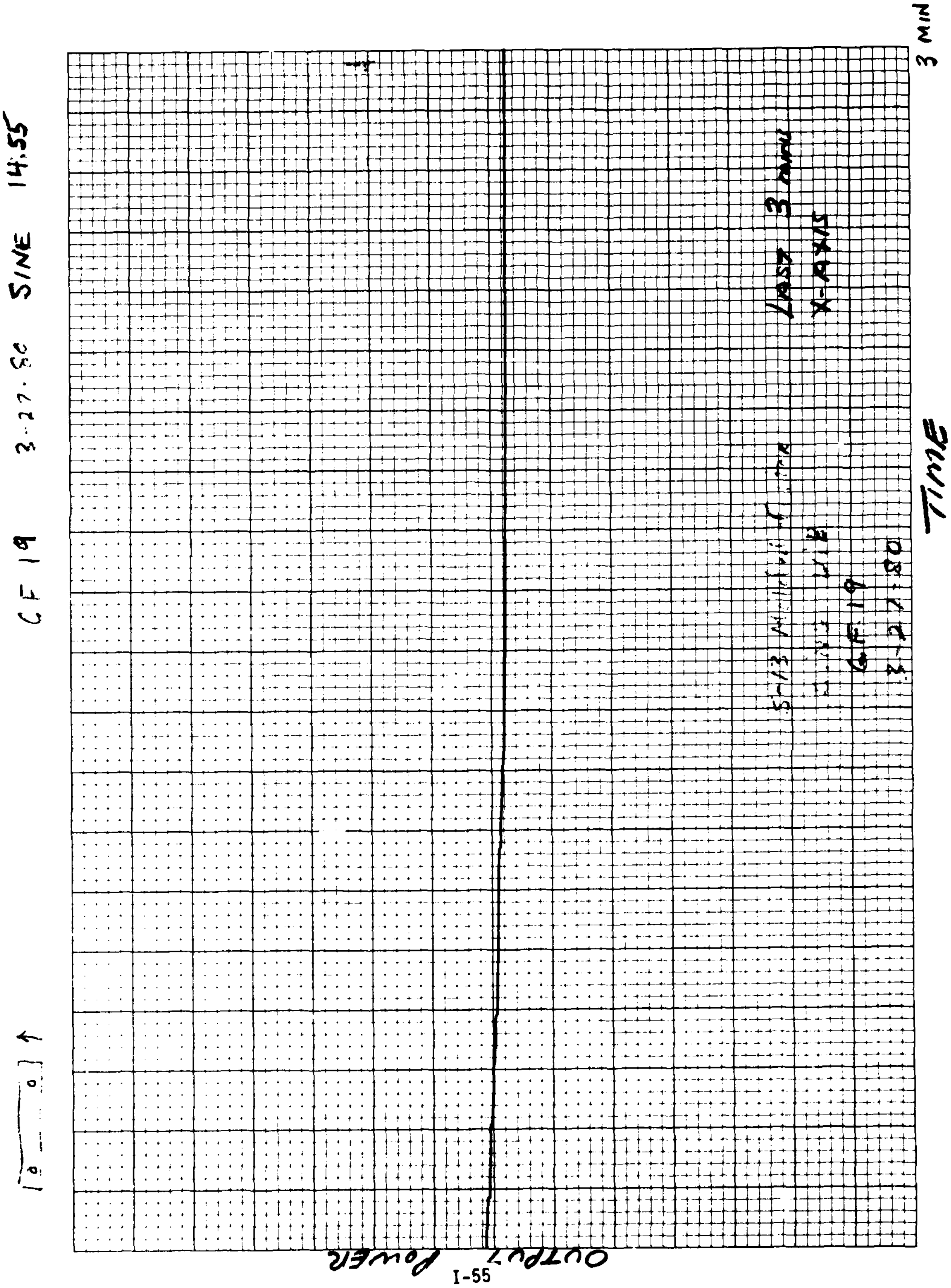

GF 17
3-28-81
1955
OUTPUT POWER
LAST 3 mins
Z-AXIS
SINE VIB
GF 17
3-28-80
TIME
3 mi

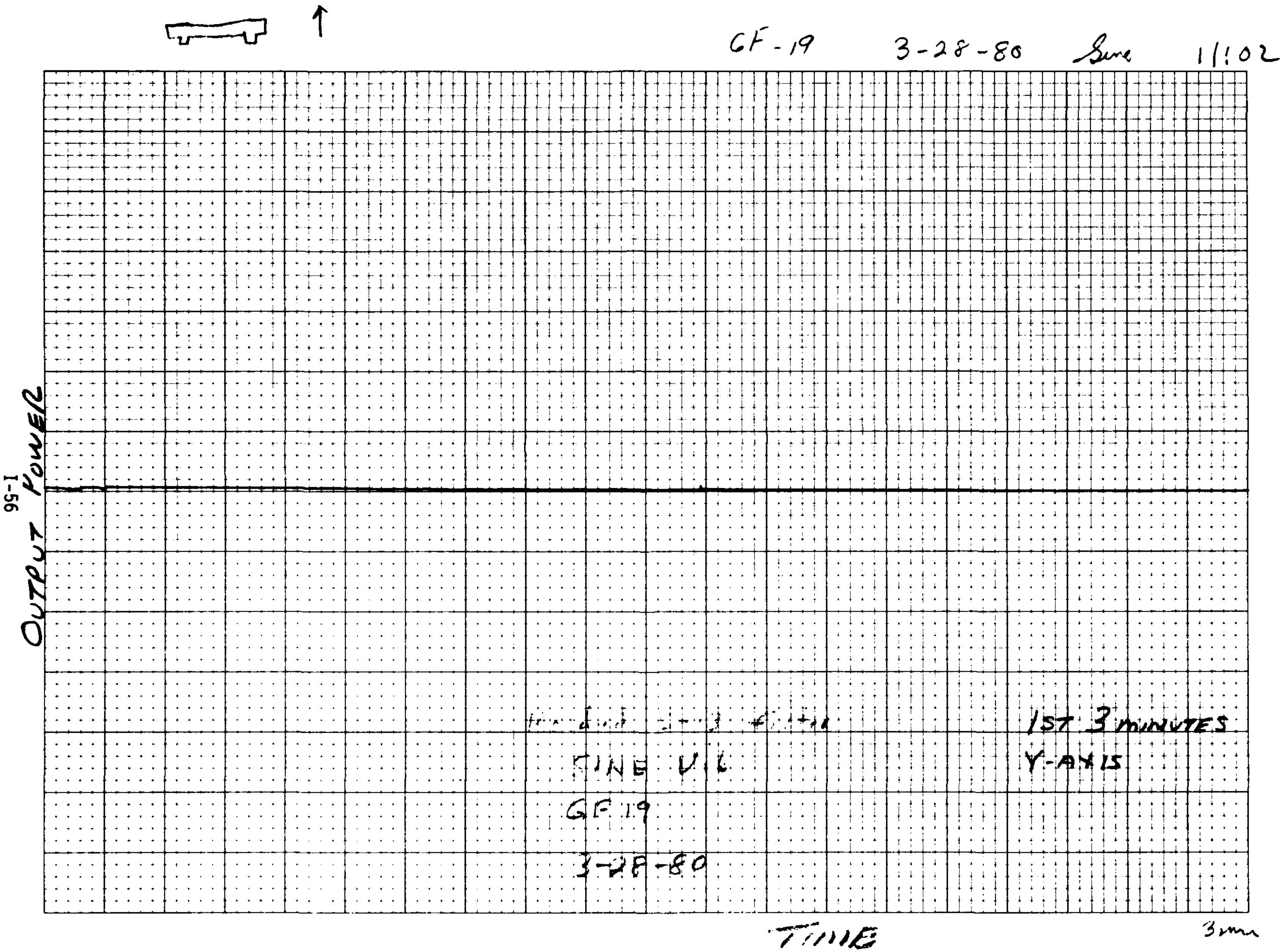

1ST 3 MINUTES
X-AXIS
TIME
OUTPUT POWER

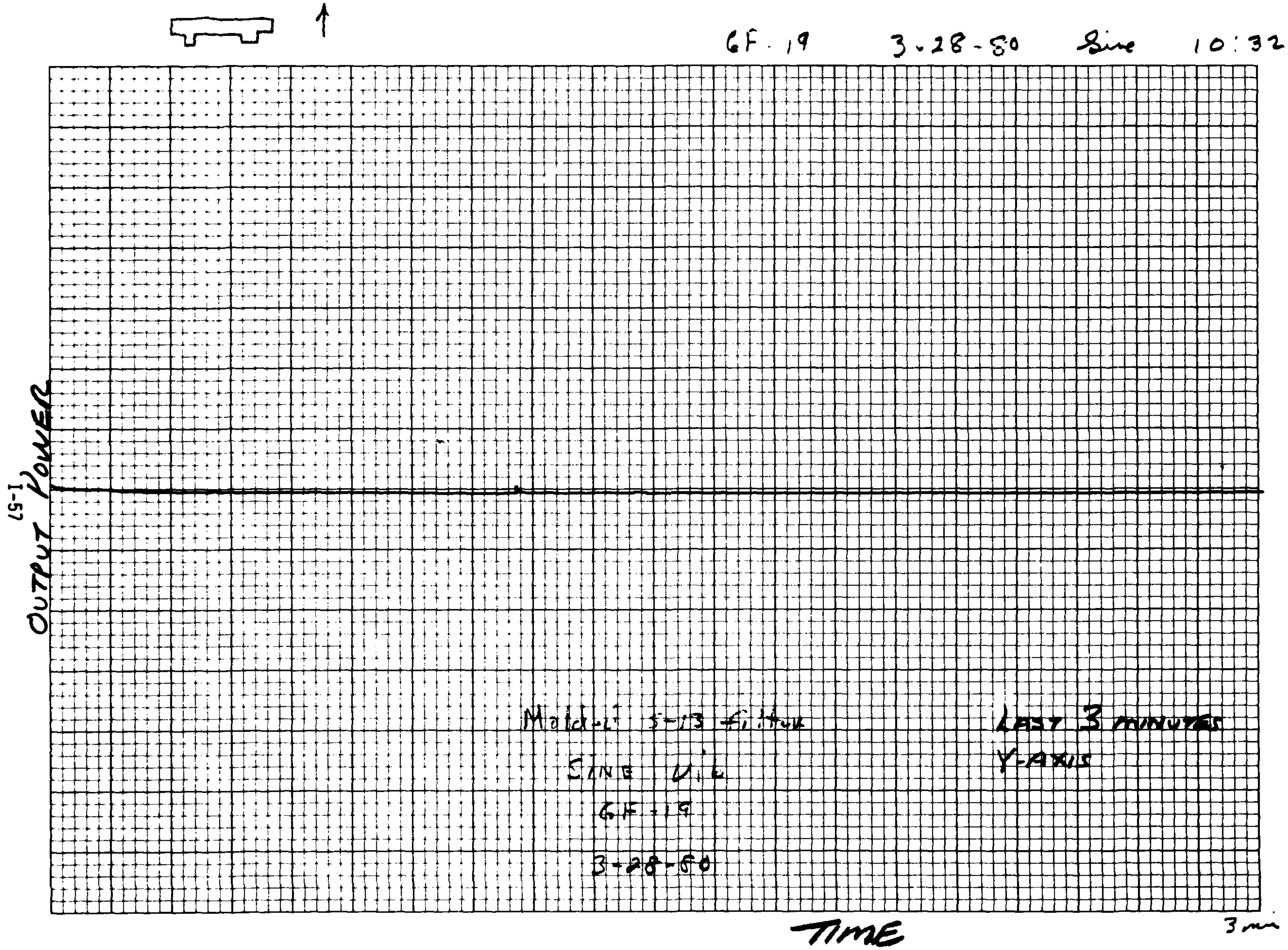

GF 19 3-27-80 Random 15:30
OUTPUT POWER
TIME
Molded I-13 filter
RANDOM Vib
GF-19
3-27-80
LAST 3 MINUTES
X-AXIS
3 mm

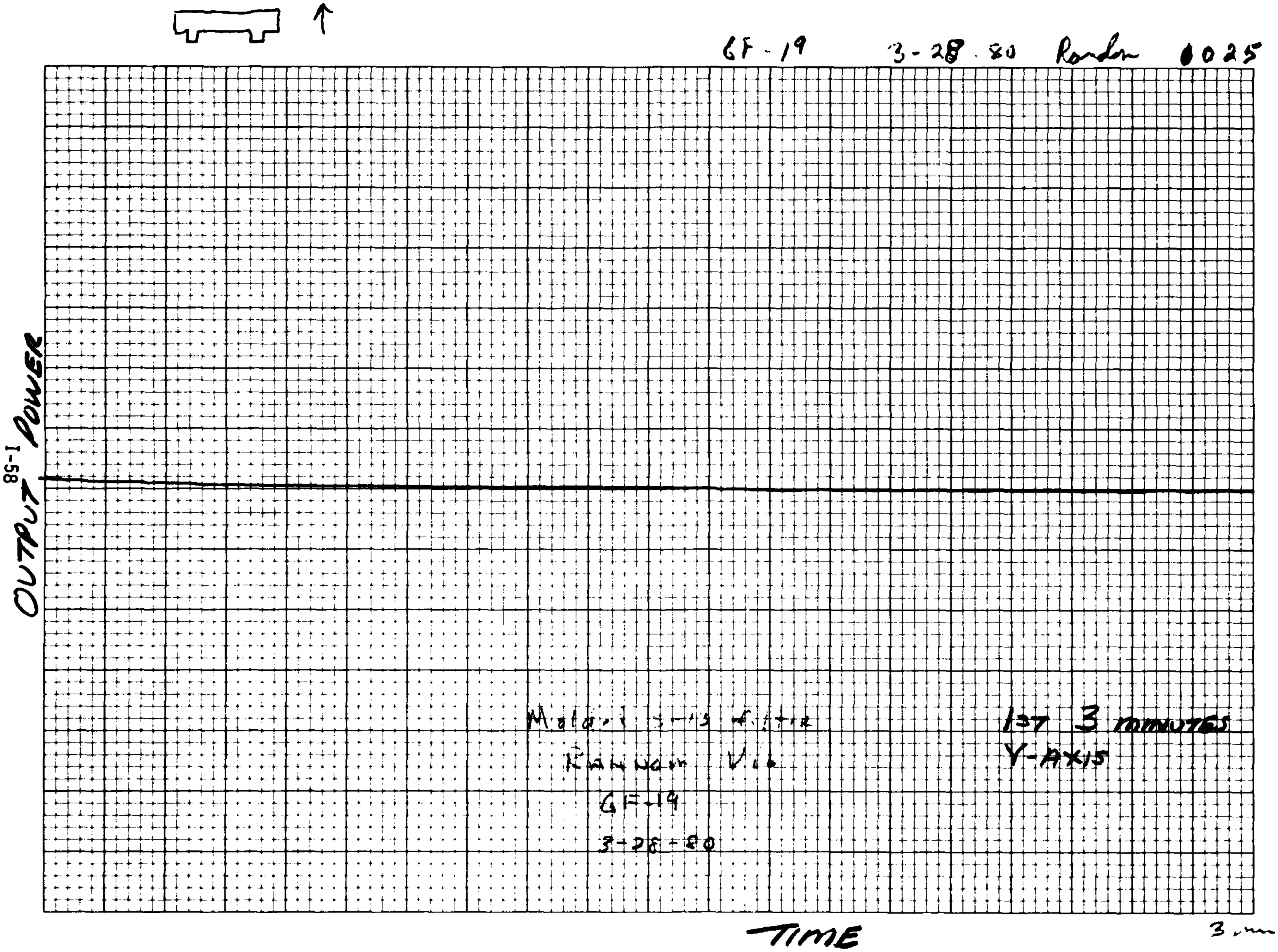


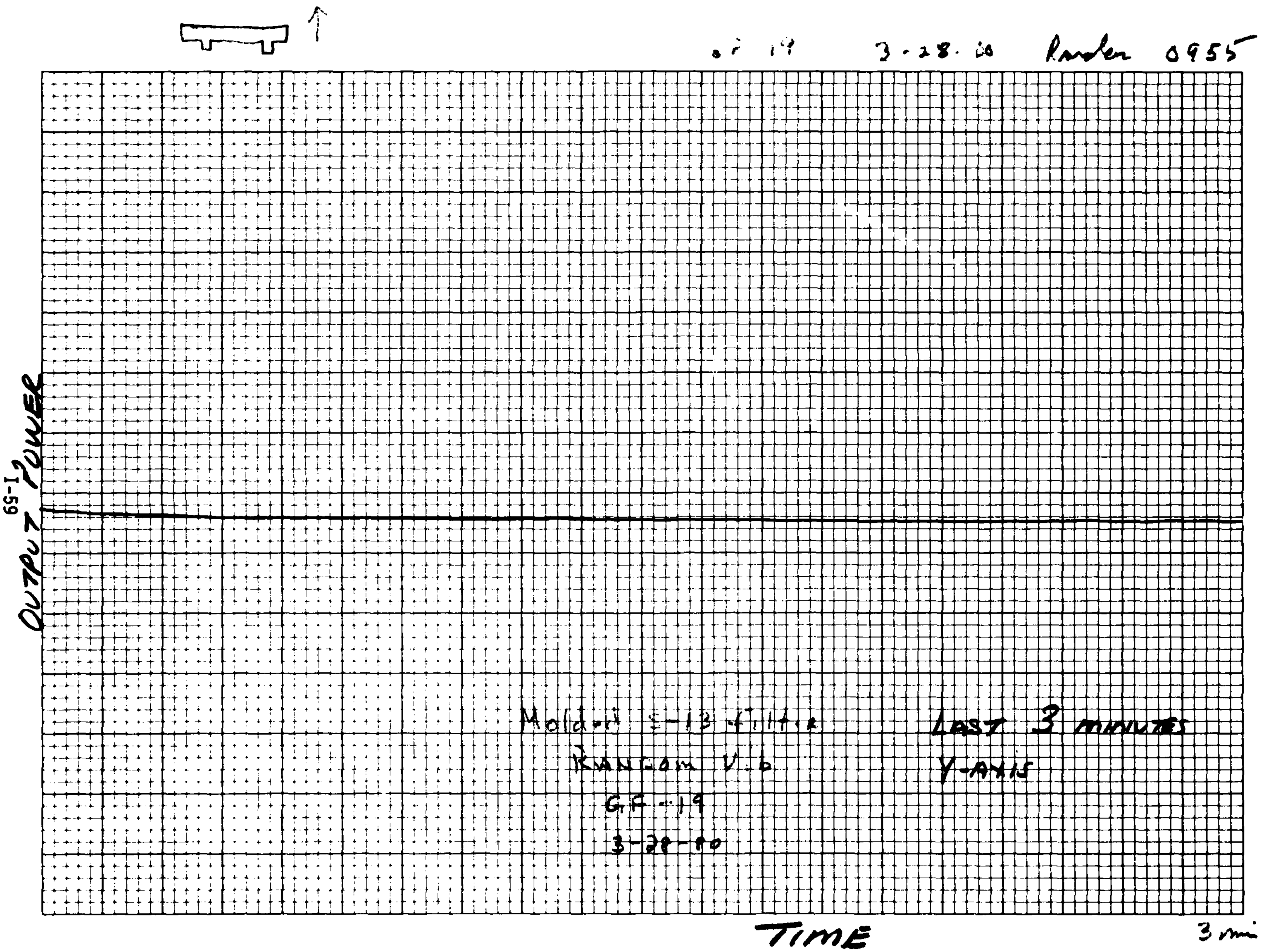
GF19 3-27-80 SINE 14.25
OUTPUT POWER
1ST 3 MINS
X-AXIS
SINE
GF-19
3-27-80
TIME
3 MIN


CF 19
3-27-80
SINE
14:55
3 MIN
LAST 3 min
X-AXIS
CF 19
3-27-80
TIME
OUTPUT POWER

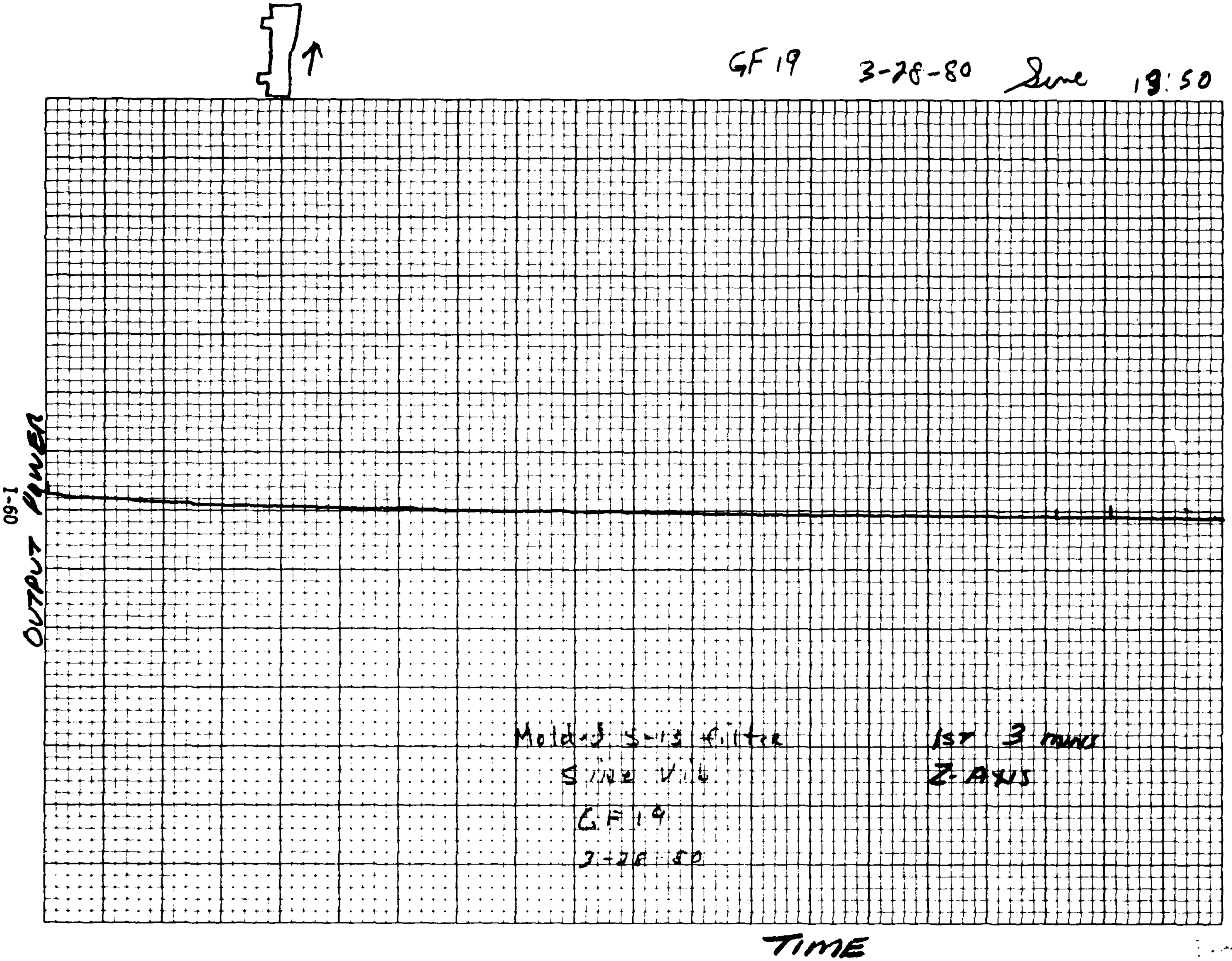

GF-19
3-28-80
11:02
OUTPUT POWER
TIME
3 min
1ST 3 MINUTES
Y-AXIS
FINE
GF 19
3-28-80

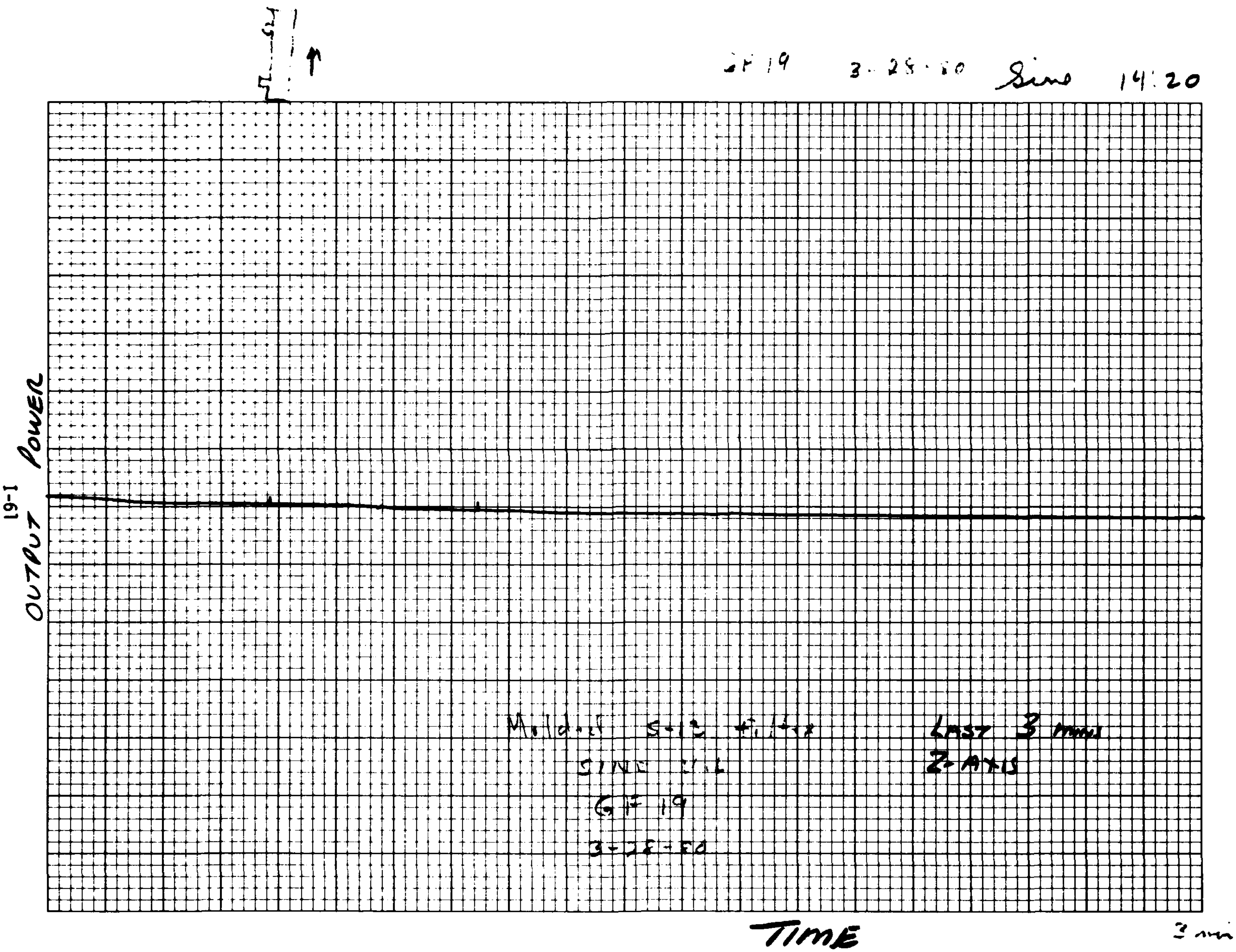

6F - 19
3-28-80
Sine
10:32
OUTPUT POWER
TIME
3 min
LAST 3 MINUTES
Y-AXIS
3-28-80

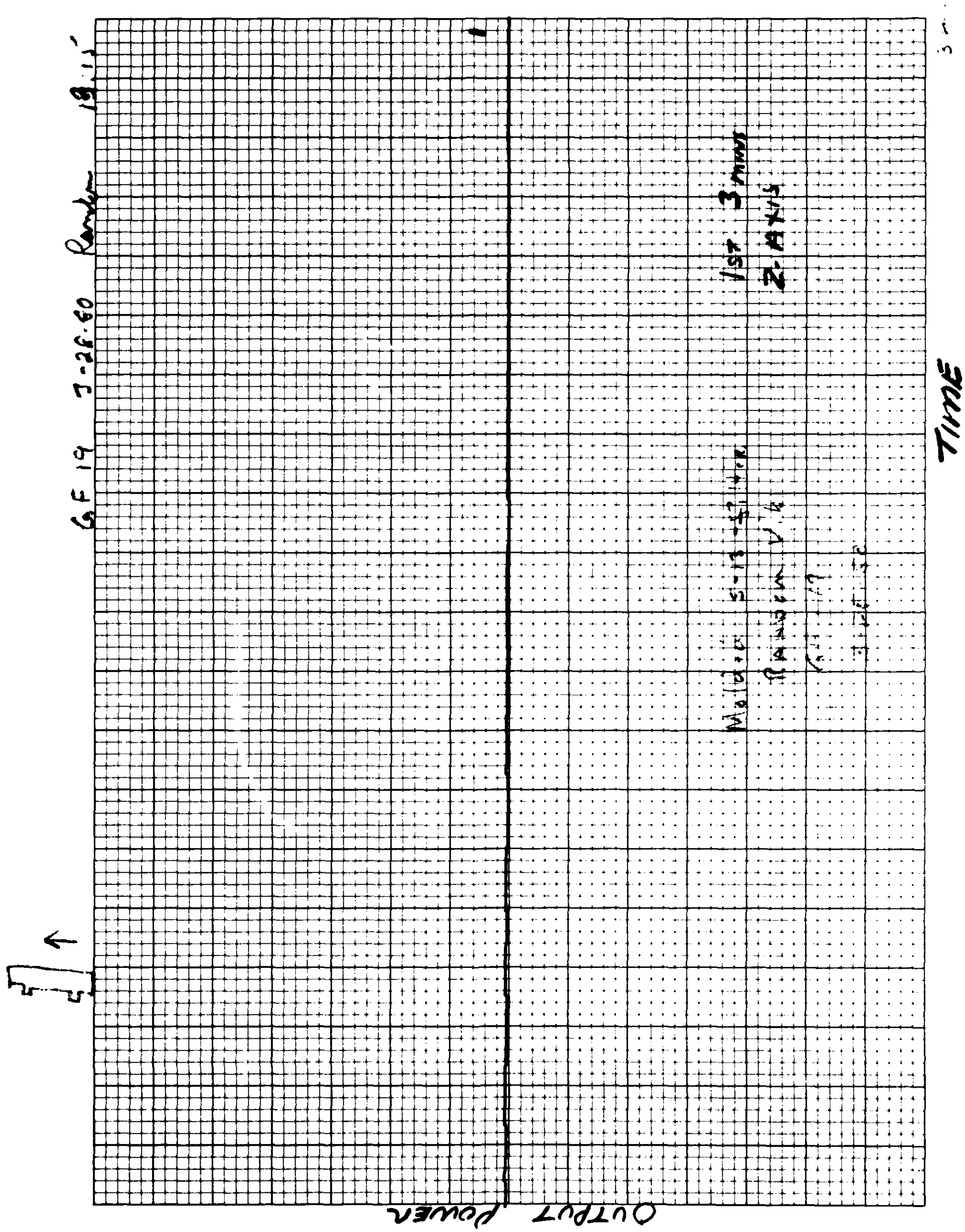

GF-19
3-28-80
1ST 3 MINUTES
Y-AXIS
GF-19
3-28-80
TIME
OUTPUT POWER



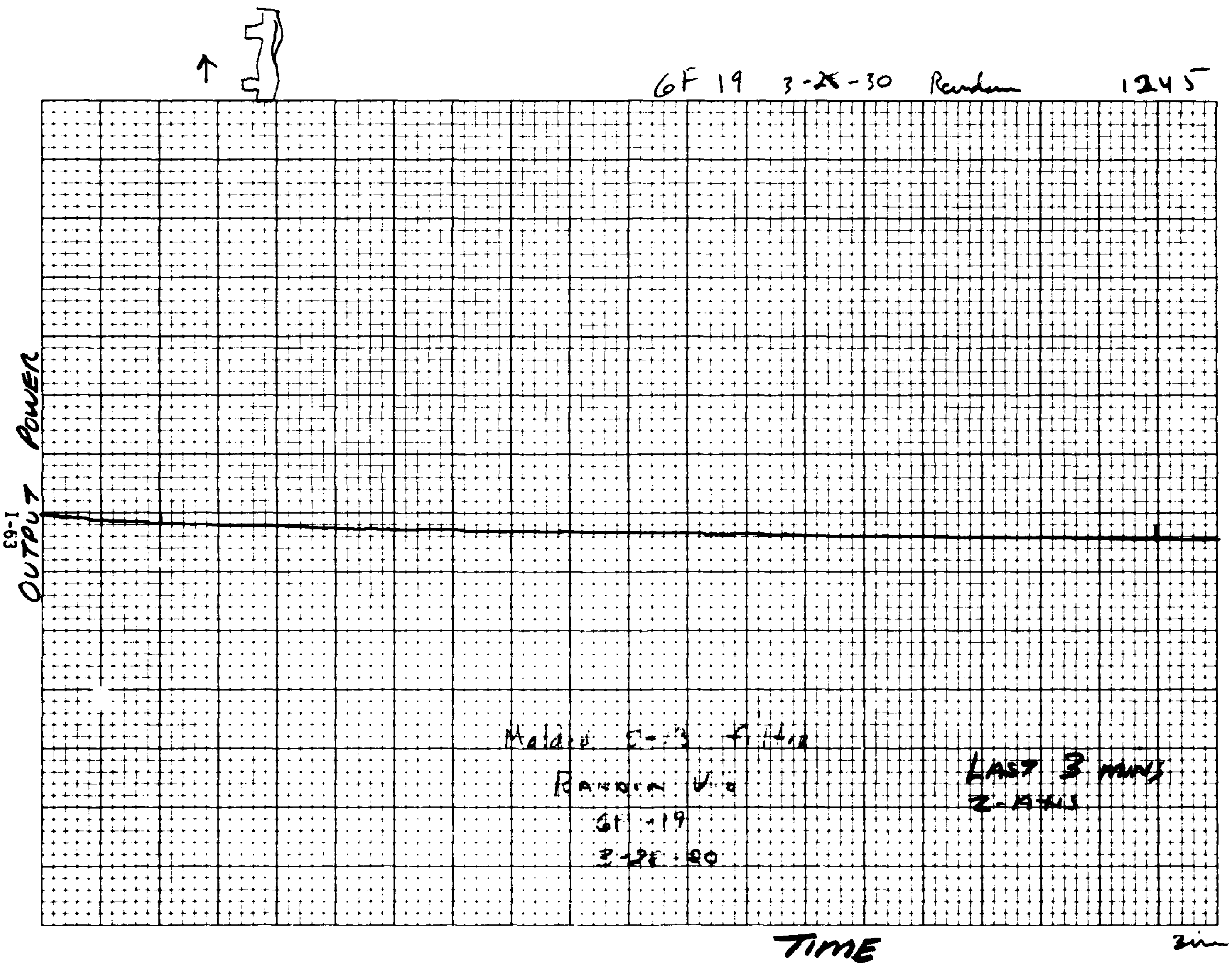
of 19
3-28-90
Rader 0955
OUTPUT POWER
Moldan E-13 filter
Random V.6
GF-19
3-28-90
LAST 3 MINUTES
Y-AXIS
TIME
3 min


GF 19 3-28-80 Sine 13:50
OUTPUT POWER
Molded S-13 Filter
Sine V.4
GF 19
3-28-80
1st 3 mins
Z AXIS
TIME


GF 19 3-28-80 Sine 14:20
OUTPUT POWER
Molded S-12 filter
GF 19
3-28-80
LAST 3 mins
Z-AXIS
TIME
3 min



1st 3 mins
Z AXIS
TIME
OUTPUT POWER


OUTPUT POWER
TIME
LAST 3 MINS
Z-AXIS

MOLDED 5-13 FILTER
GOLD PLATE
POST VIB

FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	S/N 17		S/N 13		S/N 19	
00.00	163.71	76.63	130.79	81.29	175.10	79.10
05.00	200.12	74.71	121.02	73.78	177.77	73.52
10.00	139.44	75.06	126.53	75.32	143.43	78.98
15.00	141.03	73.85	118.49	87.00	133.13	91.16
20.00	121.72	68.26	98.06	70.95	126.29	71.31
25.00	132.88	66.50	110.36	70.50	135.41	70.82
30.00	111.99	65.20	87.89	68.39	114.23	69.20
35.00	115.72	62.16	80.86	66.38	112.88	66.95
40.00	97.26	57.95	82.87	62.28	99.98	63.72
45.00	84.87	54.48	75.74	59.61	83.81	60.79
50.00	76.61	51.43	68.07	57.41	78.86	58.94
55.00	69.28	47.51	66.80	53.85	70.12	55.11
60.00	67.54	43.92	55.71	50.85	63.20	52.36
65.00	56.41	39.98	49.68	47.97	53.82	49.81
70.00	52.88	35.58	45.23	44.75	47.11	46.69
75.00	43.46	30.57	39.31	40.88	39.28	43.08
80.00	35.89	24.00	35.06	36.51	32.98	38.93
85.00	28.89	18.51	31.51	31.96	28.84	34.67
90.00	19.54	12.90	26.16	26.85	23.33	30.19
95.00	15.17	10.85	20.32	21.81	18.33	25.16
00.00	13.08	10.00	12.87	13.93	14.06	19.75
05.00	9.98	8.48	4.37	6.30	9.19	13.83
10.00	6.58	6.21	2.60	3.28	5.55	8.43
15.00	3.68	3.76	2.95	3.57	3.37	4.72
20.00	1.92	1.96	2.72	3.02	2.25	2.81
25.00	1.18	1.36	1.91	2.16	1.47	1.88
30.00	1.36	1.34	1.29	1.66	1.15	1.55
35.00	1.55	1.36	1.24	1.53	1.48	1.58
40.00	1.57	1.26	1.43	1.49	1.69	1.56
45.00	1.53	1.19	1.46	1.41	1.68	1.46
50.00	1.58	1.14	1.32	1.29	1.49	1.30
55.00	1.51	1.14	1.11	1.18	1.23	1.12
60.00	1.54	1.16	1.12	1.19	1.05	1.06
65.00	1.53	1.16	1.37	1.31	1.24	1.09
70.00	1.47	1.14	1.63	1.48	1.44	1.19
75.00	1.39	1.04	1.83	1.64	1.58	1.30
80.00	1.27	.97	1.95	1.72	1.67	1.36
85.00	1.16	.89	1.99	1.69	1.67	1.34
90.00	1.07	.87	1.94	1.60	1.62	1.30
95.00	1.08	.83	1.83	1.40	1.56	1.16
00.00	1.17	.85	1.67	1.24	1.49	1.08
05.00	1.27	.94	1.49	1.15	1.44	1.06
10.00	1.36	.96	1.31	1.05	1.39	.99
15.00	1.45	.93	1.15	.98	1.35	.93
20.00	1.51	.90	1.04	.91	1.30	.87
25.00	1.56	.97	1.11	.93	1.24	.85
30.00	1.57	.96	1.22	.97	1.19	.85
35.00	1.55	.96	1.31	1.02	1.17	.86
40.00	1.49	.91	1.38	1.03	1.20	.88
45.00	1.41	.86	1.42	1.06	1.26	.90
50.00	1.33	.85	1.43	1.06	1.33	.91
55.00	1.27	.84	1.41	1.05	1.39	.92

POST VIBRATION VSWR & LOSS
SHEET 1 OF 3

FREQ MHZ	VSWR	LOSS DB	VSWR	LOSS DB	VSWR	LOSS DB
	SN 17		SN 13		SN 19	
60.00	1.26	.83	1.37	1.04	1.43	.95
65.00	1.29	.83	1.33	1.00	1.44	.94
70.00	1.36	.87	1.29	1.00	1.43	.92
75.00	1.43	.87	1.27	.99	1.38	.88
80.00	1.49	.93	1.27	1.00	1.30	.86
85.00	1.53	.92	1.20	1.00	1.22	.84
90.00	1.55	.89	1.29	1.00	1.13	.82
95.00	1.57	.91	1.30	1.01	1.10	.83
00.00	1.59	.91	1.32	1.01	1.16	.83
05.00	1.59	.90	1.35	1.02	1.25	.85
10.00	1.56	.93	1.40	1.04	1.35	.86
15.00	1.50	.92	1.46	1.08	1.43	.88
20.00	1.40	.93	1.53	1.13	1.48	.93
25.00	1.27	.91	1.58	1.18	1.47	.94
30.00	1.14	.85	1.59	1.19	1.42	.91
35.00	1.12	.89	1.57	1.19	1.33	.90
40.00	1.25	.99	1.52	1.21	1.26	.92
45.00	1.41	1.06	1.46	1.23	1.27	.97
50.00	1.55	1.14	1.41	1.21	1.35	.99
55.00	1.60	1.16	1.39	1.20	1.44	1.04
60.00	1.57	1.15	1.39	1.20	1.51	1.05
65.00	1.51	1.11	1.37	1.25	1.49	1.07
70.00	1.50	1.12	1.30	1.26	1.37	1.07
75.00	1.59	1.21	1.18	1.24	1.22	1.01
80.00	1.65	1.31	1.12	1.28	1.27	1.06
85.00	1.50	1.34	1.33	1.41	1.57	1.24
90.00	1.30	1.56	1.67	1.67	1.92	1.49
95.00	2.22	2.44	2.03	1.96	2.12	1.66
00.00	4.86	4.71	2.32	2.28	1.99	1.65
05.00	9.00	7.57	2.40	2.46	1.57	1.52
10.00	11.41	10.05	2.30	2.56	1.69	1.82
15.00	8.00	11.71	2.05	2.73	3.02	3.02
20.00	4.22	13.49	1.57	3.22	4.89	4.36
25.00	5.44	18.34	2.20	5.54	6.16	5.30
30.00	12.85	24.93	6.37	11.25	12.31	8.73
35.00	22.10	31.19	15.60	19.21	44.86	16.55
40.00	49.70	36.71	27.02	24.51	112.24	23.87
45.00	90.49	41.71	43.49	30.22	225.07	30.12
50.00	130.10	46.21	66.82	35.35	392.63	35.56
55.00	322.90	50.45	96.92	40.18	728.41	40.56
60.00	349.99	54.66	100.16	44.70	683.48	45.15
65.00	366.51	58.27	100.34	48.89	850.98	49.37
70.00	373.37	62.34	118.84	52.95	556.96	53.74
75.00	460.85	66.28	120.14	56.76	526.85	57.01
80.00	426.22	69.41	125.70	60.42	534.86	61.76
85.00	253.02	74.88	112.37	65.55	315.66	66.36
90.00	312.02	76.62	125.59	69.39	464.87	68.91
95.00	376.17	78.37	123.77	70.51	366.34	71.70
00.00	350.73	74.26	114.18	70.92	284.05	72.49
05.00	323.06	75.31	134.15	71.93	420.35	70.92
10.00	251.00	72.61	102.42	72.21	221.76	72.03
15.00	222.10	73.31	116.32	72.15	265.85	73.17

POST VIBRATION VSWR & LOSS
SHEET 2-OF 3

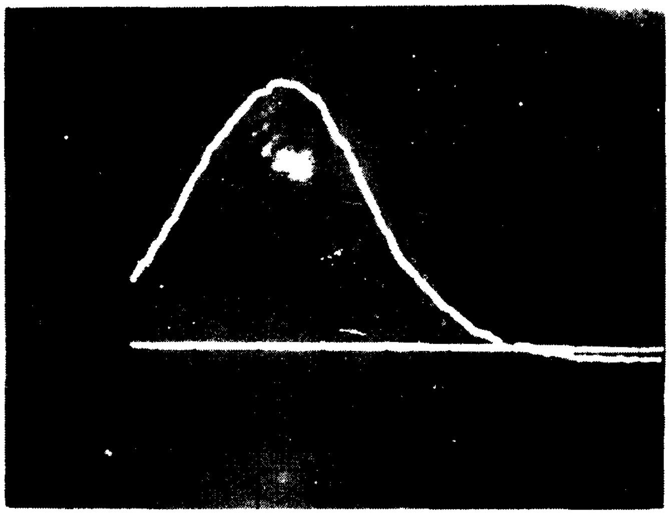
FREQ MHZ	SN 17 VSWR	SN 17 LOSS DB	SN 13 VSWR	SN 13 LOSS DB	SN 11 VSWR	SN 11 LOSS DB
20.00	100.56	70.69	90.12	78.52	104.42	79.08
25.00	152.95	93.19	86.58	87.47	170.64	86.44
30.00	137.22	79.64	91.30	82.89	143.41	82.49
35.00	131.10	78.76	82.36	80.92	138.07	79.00
40.00	110.44	70.56	72.73	78.92	109.03	81.91
45.00	92.03	77.57	70.53	79.26	100.44	79.41
50.00	83.56	75.46	64.25	75.26	92.84	75.72

POST VIBRATION VSWR & LOSS

SHEET 3 OF 3

ANNEX C

SHOCK DATA

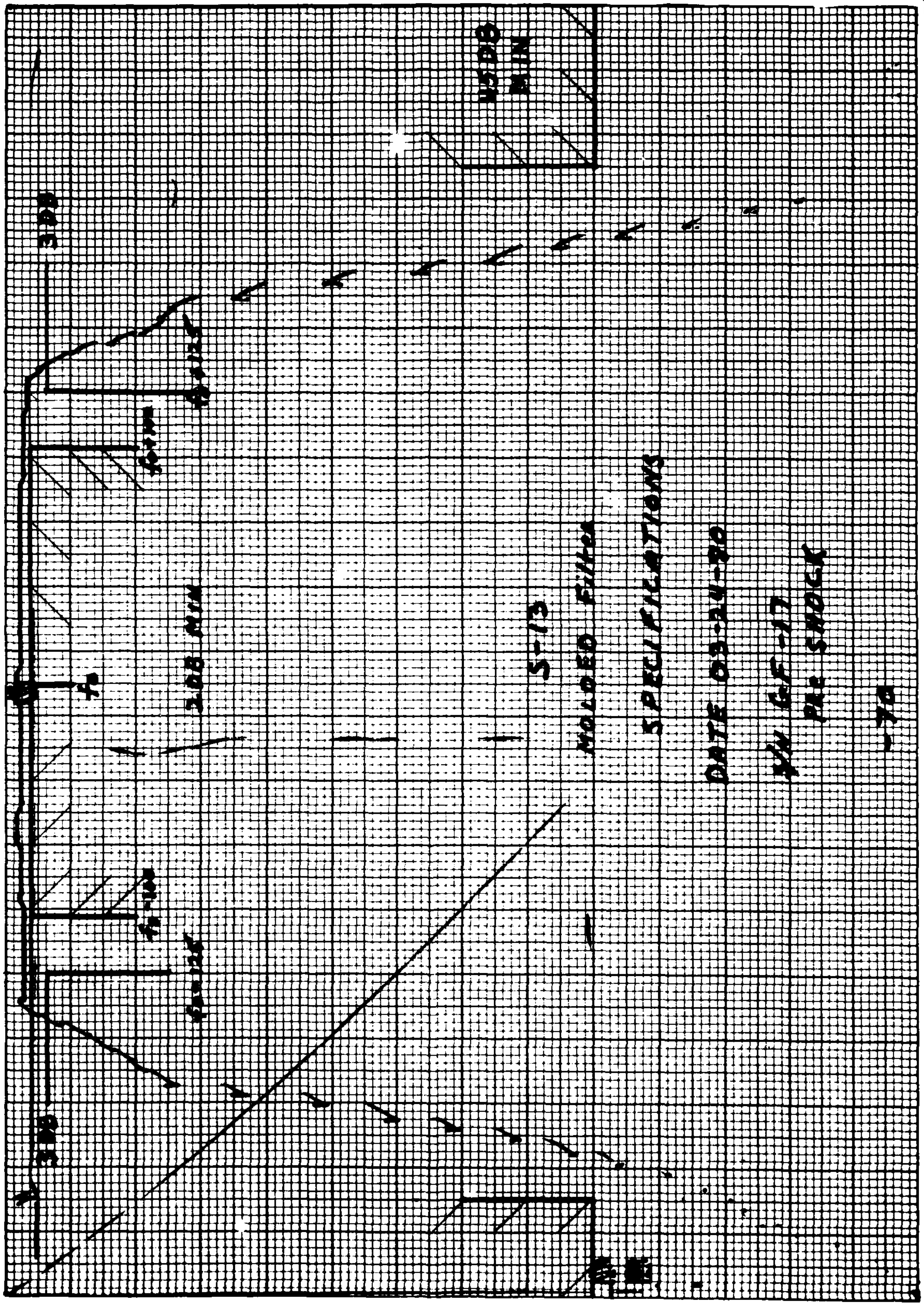


SHOCK PULSE

VERT 10g/cm

HORIZ 2ms/cm

2750


3DB
3DB
2DB MIN
S-13
MOLDED FILTER
SPECIFICATIONS
DATE 03-24-80
PRE SHOCK
-70

03/24/80
MOLDED S-13 FILTER
GOLD PLATE
GF17

FREQ MHZ	VSWR	LOSS DB
00.00	54.70	73.29
05.00	56.77	69.92
10.00	58.06	67.30
15.00	59.07	66.50
20.00	56.70	63.61
25.00	53.64	60.69
30.00	58.34	57.93
35.00	59.26	56.35
40.00	61.60	55.24
45.00	58.97	53.49
50.00	66.52	50.79
55.00	71.70	47.30
60.00	73.31	43.56
65.00	76.12	39.34
70.00	70.60	34.72
75.00	72.26	29.91
80.00	57.42	24.36
85.00	40.80	18.31
90.00	25.87	12.93
95.00	18.21	10.52
00.00	14.90	9.50
05.00	11.03	8.18
10.00	7.00	6.19
15.00	3.90	3.98
20.00	2.15	2.20
25.00	1.32	1.31
30.00	1.35	1.19
35.00	1.56	1.30
40.00	1.64	1.32
45.00	1.61	1.30
50.00	1.55	1.24
55.00	1.50	1.17
60.00	1.47	1.14
65.00	1.43	1.10
70.00	1.39	1.00
75.00	1.34	.98
80.00	1.27	.97
85.00	1.19	.93
90.00	1.12	.83
95.00	1.08	.79
00.00	1.14	.76
05.00	1.23	.80
10.00	1.34	.85
15.00	1.44	.96
20.00	1.54	1.03
25.00	1.61	1.06
30.00	1.63	1.08
35.00	1.61	1.06
40.00	1.54	1.00
45.00	1.46	.93
50.00	1.36	.85
55.00	1.30	.80

PRE SHOCK
#17

1 of 3

FREQ MHZ	VSWR	LOSS DB
60.00	1.31	.77
65.00	1.37	.82
70.00	1.45	.87
75.00	1.53	.93
80.00	1.58	.95
85.00	1.61	.97
90.00	1.62	.96
95.00	1.61	.95
00.00	1.61	.95
05.00	1.62	.92
10.00	1.61	.95
15.00	1.58	.96
20.00	1.49	.95
25.00	1.37	.92
30.00	1.23	.89
35.00	1.17	.89
40.00	1.28	.94
45.00	1.47	1.01
50.00	1.64	1.11
55.00	1.74	1.20
60.00	1.74	1.25
65.00	1.65	1.24
70.00	1.61	1.28
75.00	1.67	1.35
80.00	1.76	1.43
85.00	1.67	1.46
90.00	1.42	1.57
95.00	2.13	2.45
00.00	4.58	4.76
05.00	8.46	7.76
10.00	10.68	10.21
15.00	8.41	11.61
20.00	4.19	12.57
25.00	4.96	17.28
30.00	11.51	24.55
35.00	20.84	31.21
40.00	28.82	36.91
45.00	40.93	42.09
50.00	51.95	46.99
55.00	65.73	52.05
60.00	96.09	56.78
65.00	113.10	60.47
70.00	124.99	65.30
75.00	152.65	71.07
80.00	147.45	77.33
85.00	206.43	76.04
90.00	171.75	76.59
95.00	198.72	73.63
00.00	273.72	74.04
05.00	359.13	69.87
10.00	348.55	68.39
15.00	366.34	67.58

PRE SHOCK

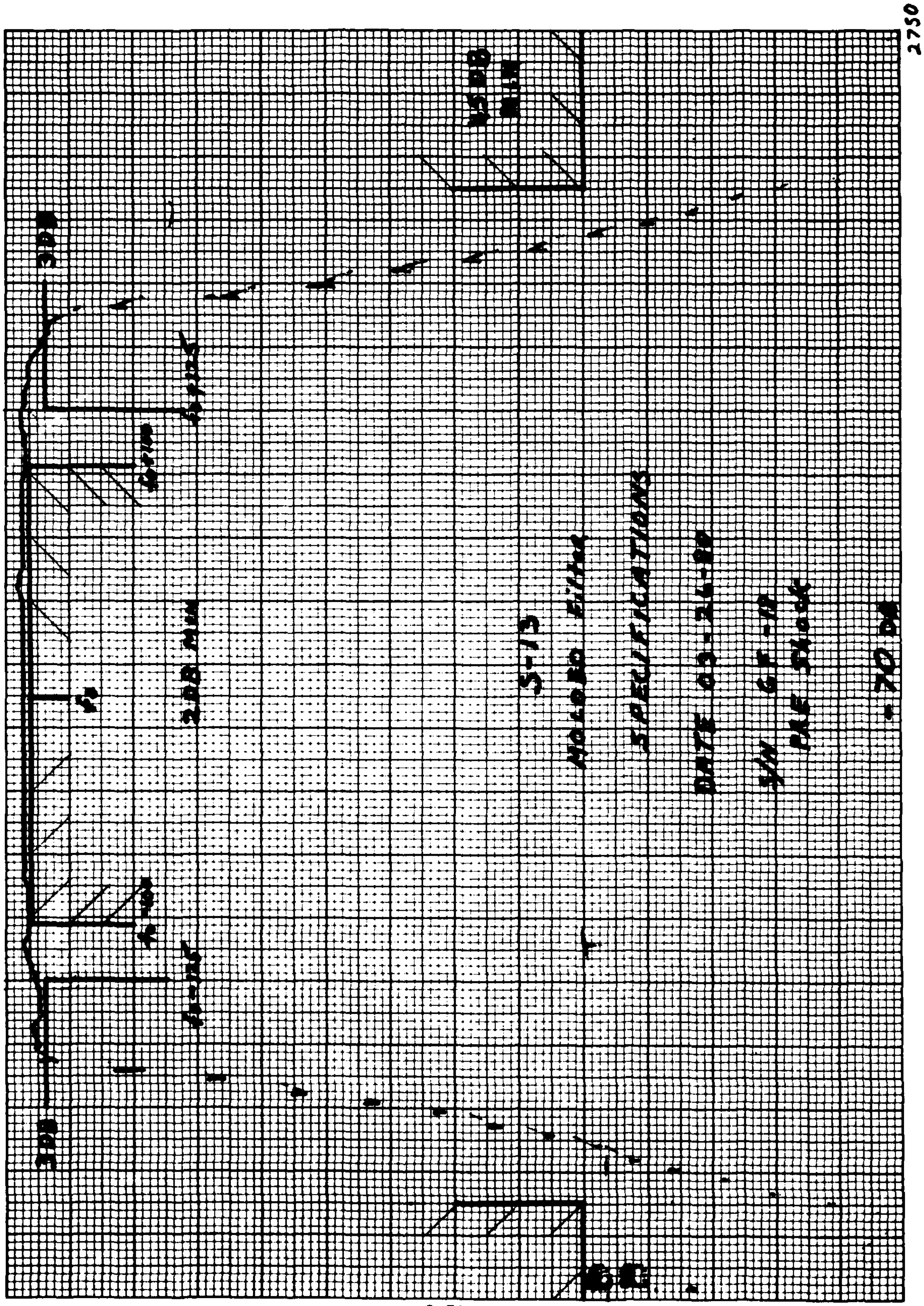
#17

2 of 3

FREQ MHZ	VSWR	LOSS DB
20.00	247.67	67.58
25.00	177.54	71.16
30.00	147.67	72.63
35.00	112.25	73.82
40.00	91.03	77.58
45.00	76.71	76.78
50.00	70.77	74.08

PRE SHOCK
#17

3 of 3


2750
3DB
2DB MAX
SPECIFICATIONS
- 70 DB

01/26/80 SKB
1056/GODFREY

S-13 MOULDED FILTER
GF-10

FREQ MHZ	VSWR	LOSS DB
00.00	98.10	71.47
05.00	101.77	68.95
10.00	102.05	66.93
15.00	91.22	66.53
20.00	86.70	66.23
25.00	82.72	67.53
30.00	85.96	68.30
35.00	88.69	67.32
40.00	95.64	64.12
45.00	88.64	60.11
50.00	87.44	56.03
55.00	80.40	52.06
60.00	79.53	48.87
65.00	77.92	45.81
70.00	70.37	42.31
75.00	67.43	38.18
80.00	55.45	33.65
85.00	43.80	28.60
90.00	33.65	22.96
95.00	19.23	16.53
00.00	7.92	9.24
05.00	2.27	3.53
10.00	1.15	2.02
15.00	1.06	1.67
20.00	1.33	1.62
25.00	1.93	1.93
30.00	2.43	2.15
35.00	2.55	2.13
40.00	2.29	1.02
45.00	1.87	1.42
50.00	1.47	1.13
55.00	1.29	1.03
60.00	1.43	1.10
65.00	1.63	1.21
70.00	1.75	1.28
75.00	1.74	1.29
80.00	1.62	1.18
85.00	1.44	1.01
90.00	1.24	.92
95.00	1.00	.83
00.00	1.14	.85
05.00	1.29	.93
10.00	1.42	.95
15.00	1.53	1.02
20.00	1.59	.99
25.00	1.61	1.01
30.00	1.60	1.00
35.00	1.56	.99
40.00	1.50	.94
45.00	1.42	.91
50.00	1.34	.86
55.00	1.27	.84

PRE SHOCK SN 18

1 OF 3

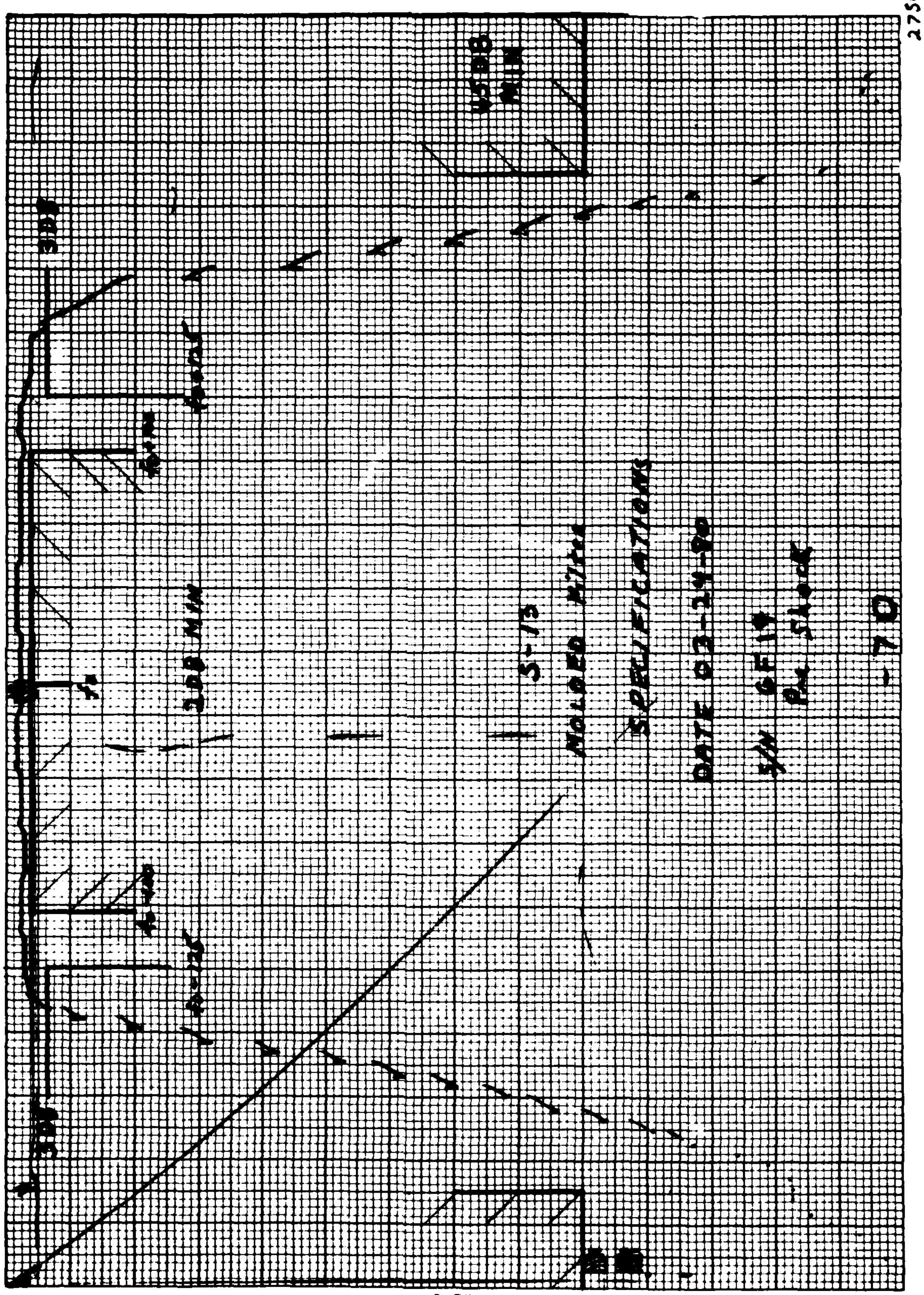
FREQ MHZ	VSNR	LOSS DB
60.00	1.22	.85
65.00	1.22	.85
70.00	1.25	.84
75.00	1.31	.86
80.00	1.37	.89
85.00	1.40	.91
90.00	1.41	.92
95.00	1.38	.90
00.00	1.33	.85
05.00	1.27	.82
10.00	1.22	.82
15.00	1.20	.81
20.00	1.22	.85
25.00	1.25	.89
30.00	1.26	.86
35.00	1.24	.87
40.00	1.21	.91
45.00	1.23	.97
50.00	1.32	1.03
55.00	1.44	1.09
60.00	1.50	1.15
65.00	1.65	1.21
70.00	1.61	1.19
75.00	1.47	1.11
80.00	1.24	1.03
85.00	1.08	1.03
90.00	1.24	1.13
95.00	1.44	1.28
00.00	1.52	1.39
05.00	1.45	1.47
10.00	1.65	1.79
15.00	2.32	2.44
20.00	2.70	2.96
25.00	1.91	3.06
30.00	6.21	8.11
35.00	20.95	16.00
40.00	36.93	24.13
45.00	51.30	30.35
50.00	61.19	35.80
55.00	64.82	40.93
60.00	76.52	45.65
65.00	72.52	49.56
70.00	75.57	53.25
75.00	73.30	56.70
80.00	77.10	60.40
85.00	80.09	64.63
90.00	82.99	68.82
95.00	84.55	72.22
00.00	89.54	73.49
05.00	90.97	75.20
10.00	105.06	79.85
15.00	100.40	77.37

PRE SHOCK #18
2 of 3

FREQ MHZ	VSWR	LOSS DB
20.00	93.95	79.46
25.00	102.41	85.26
30.00	107.07	89.76
35.00	97.65	86.15
40.00	101.00	89.43
45.00	102.54	89.04
50.00	100.41	83.89

PRE SHOCK S/N 18

SHEET 3 OF 3



3DB
3DB
USBB MIN
200 MIN
S-75
MOLDED Filter
SPECIFICATIONS
DATE 03-24-80
S/N GF19
Pa Shock
-70

03/29/80
MOLDED S-13 FILTER
GOLD PLATE
GF19

FREQ MHZ	VSWR	LOSS DB
00.00	57.85	73.43
05.00	55.29	70.21
10.00	50.83	68.10
15.00	58.11	69.22
20.00	57.79	66.10
25.00	54.99	64.20
30.00	58.23	62.45
35.00	57.96	61.00
40.00	63.75	61.24
45.00	59.05	60.90
50.00	67.40	59.15
55.00	69.84	56.61
60.00	71.72	53.57
65.00	73.54	50.30
70.00	66.12	46.57
75.00	62.33	42.00
80.00	47.51	39.08
85.00	40.13	34.99
90.00	30.77	30.68
95.00	23.00	25.98
00.00	16.20	20.92
05.30	10.43	15.60
10.00	6.42	10.13
15.00	3.77	5.76
20.00	2.30	3.02
25.00	1.48	1.79
30.00	1.11	1.38
35.00	1.33	1.32
40.00	1.51	1.30
45.00	1.51	1.27
50.00	1.38	1.16
55.00	1.19	1.05
60.00	1.09	1.00
65.00	1.22	1.02
70.00	1.36	1.04
75.00	1.49	1.08
80.00	1.55	1.15
85.00	1.57	1.19
90.00	1.55	1.17
95.00	1.52	1.16
00.00	1.50	1.07
05.00	1.46	1.00
10.00	1.42	.91
15.00	1.36	.88
20.00	1.20	.83
25.00	1.20	.78
30.00	1.11	.78
35.00	1.00	.78
40.00	1.14	.81
45.00	1.22	.82
50.00	1.31	.87
55.00	1.30	.87

PRE SHOCK
#19
1 of 3

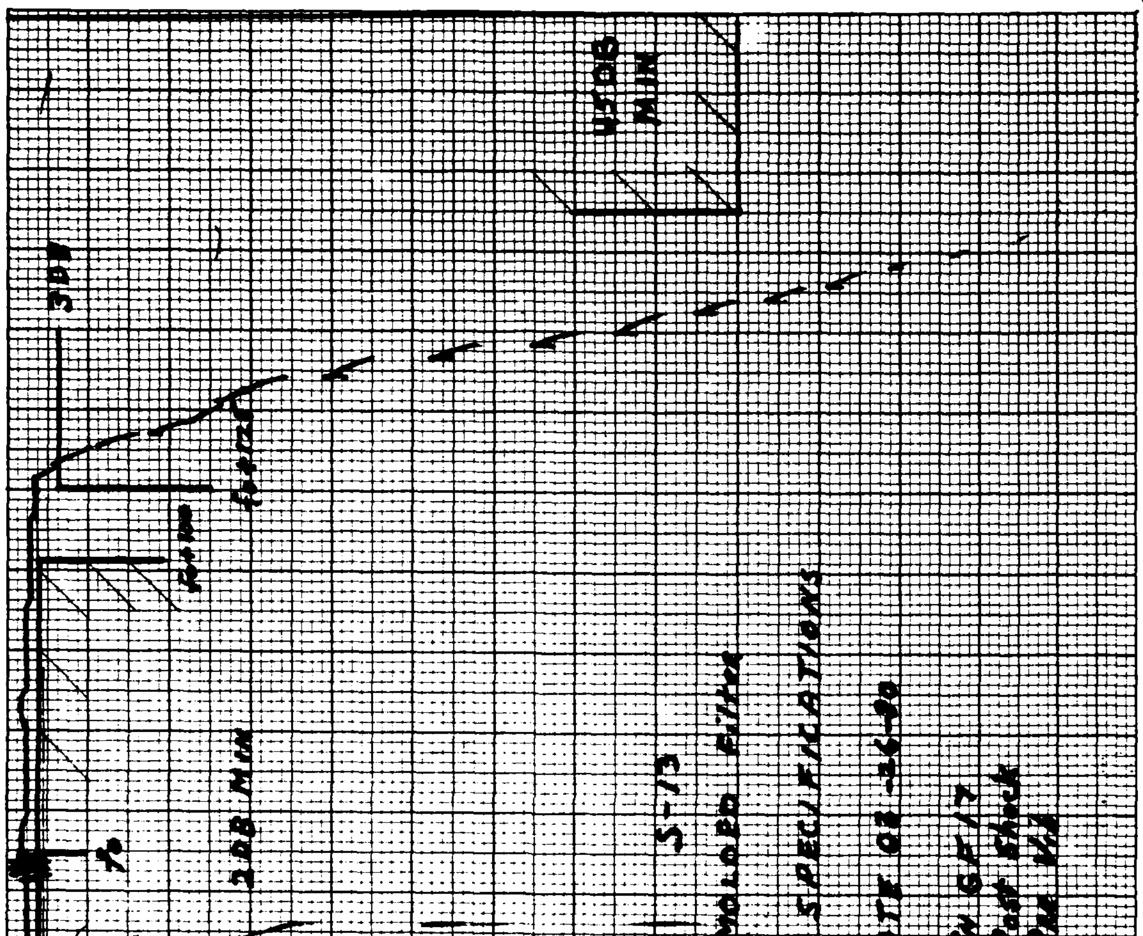
FREQ MHZ	VSWR	LOSS DB
60.00	1.44	.88
65.00	1.46	.87
70.00	1.45	.87
75.00	1.43	.83
80.00	1.38	.83
85.00	1.31	.76
90.00	1.24	.72
95.00	1.19	.73
00.00	1.20	.72
05.00	1.27	.73
10.00	1.36	.81
15.00	1.47	.87
20.00	1.55	.91
25.00	1.59	.93
30.00	1.57	.91
35.00	1.50	.94
40.00	1.40	.96
45.00	1.34	.97
50.00	1.37	.99
55.00	1.48	1.05
60.00	1.60	1.10
65.00	1.64	1.10
70.00	1.58	1.08
75.00	1.43	1.05
80.00	1.33	1.07
85.00	1.52	1.24
90.00	1.92	1.51
95.00	2.29	1.80
00.00	2.36	1.89
05.00	2.01	1 80
10.00	1.69	1.80
15.00	2.61	2.69
20.00	4 66	4.30
25.00	6.44	5.48
30.00	8.46	7.44
35.00	21.16	13.90
40.00	37.84	21.68
45.00	55.73	28.33
50.00	71.74	34.25
55.00	93.91	39.65
60.00	143 00	44.55
65.00	163.65	48.86
70.00	189.90	53.20
75.00	198.73	58.20
80.00	207.56	63.47
85.00	302.42	69.74
90.00	267.64	72.30
95.00	263.35	73.45
00.00	567.33	72.05
05.00	891.36	68.93
10.00	072 54	67.94
15.00	988.43	66.87

PRE SHOCK
#19
2 OF 3

FREQ MHZ	VSWR	LOSS DB
20.00	387.45	67.04
25 00	193.60	70.98
30.00	191.01	72.69
35.00	140.57	73.36
40.00	115.37	70.29
45 00	95.94	76.14
50.00	84.91	75.30

PRE SHOCK
#19

3 of 3


3DB
2DB MIN
45DB MIN
MOLDED FILTER
SPECIFICATIONS
2750

03/26/88
MOLDED S-13 FILTER
GOLD PLATE
POST SHOCK 17

FREQ MHZ	VSWR	LOSS DB
00.00	65.45	79.79
05.00	65.55	78.96
10.00	68.29	74.28
15.00	67.41	70.36
20.00	66.51	70.00
25.00	58.91	66.30
30.00	54.25	64.05
35.00	55.60	60.26
40.00	57.69	57.06
45.00	58.69	53.79
50.00	59.30	50.45
55.00	61.20	46.92
60.00	60.03	43.06
65.00	59.09	39.11
70.00	54.44	34.62
75.00	49.62	29.67
80.00	46.03	23.91
85.00	33.03	17.40
90.00	23.10	11.92
95.00	17.95	10.59
00.00	14.51	9.96
05.00	10.36	8.39
10.00	6.49	5.99
15.00	3.59	3.42
20.00	1.92	1.72
25.00	1.25	1.29
30.00	1.39	1.34
35.00	1.56	1.39
40.00	1.56	1.29
45.00	1.49	1.19
50.00	1.43	1.11
55.00	1.41	1.02
60.00	1.41	.96
65.00	1.43	.88
70.00	1.41	.80
75.00	1.36	.76
80.00	1.29	.73
85.00	1.19	.69
90.00	1.09	.68
95.00	1.02	.71
00.00	1.12	.69
05.00	1.24	.71
10.00	1.35	.75
15.00	1.45	.77
20.00	1.54	.77
25.00	1.58	.80
30.00	1.60	.84
35.00	1.58	.90
40.00	1.52	.94
45.00	1.45	.93
50.00	1.30	.91
55.00	1.32	.87

POST SHOCK #17

1 of 3

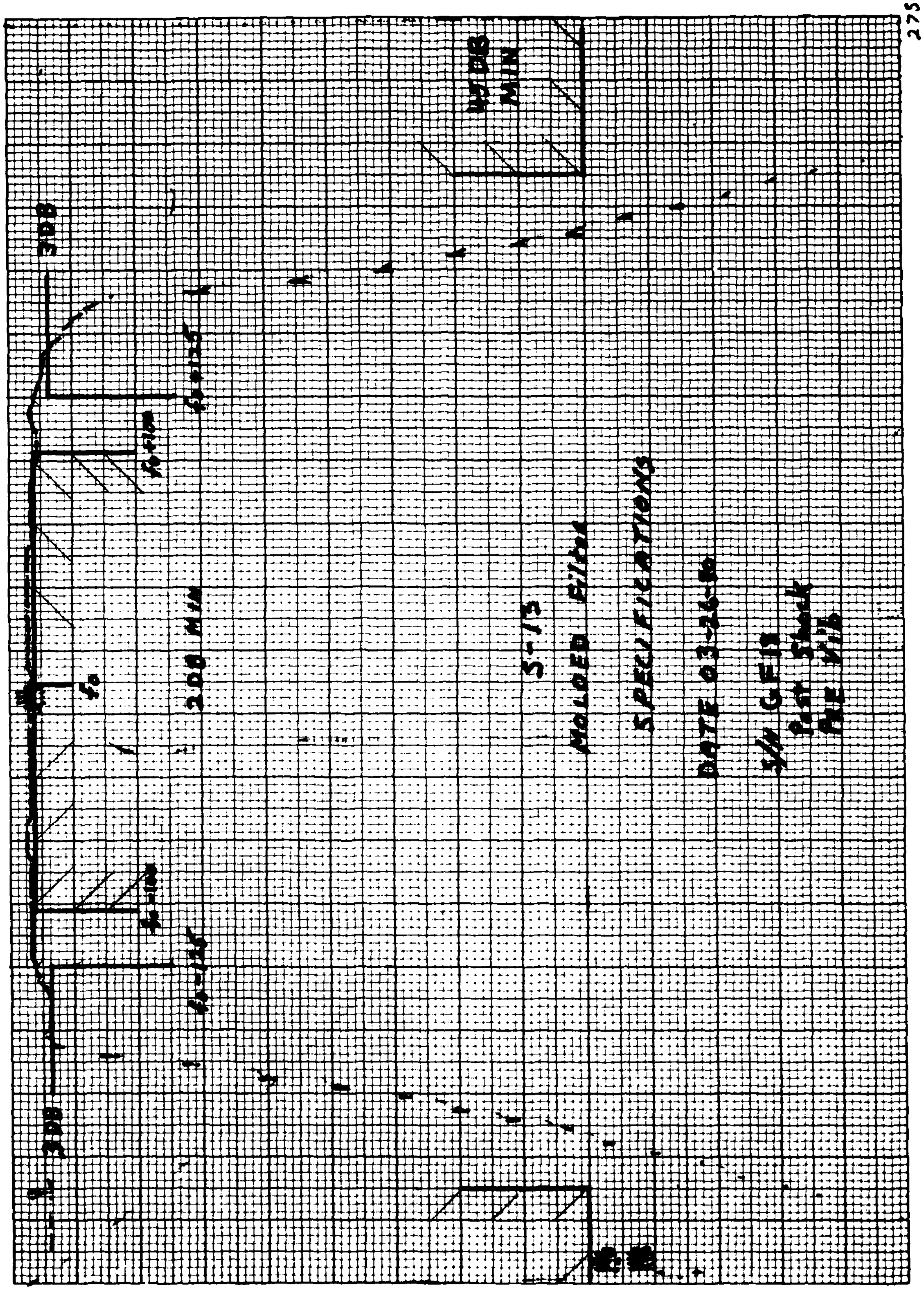
FREQ MHZ	VSWR	LOSS DB
60.00	1.29	.80
65.00	1.30	.77
70.00	1.34	.76
75.00	1.40	.82
80.00	1.47	.90
85.00	1.53	.98
90.00	1.57	1.05
95.00	1.60	1.03
00.00	1.61	.95
05.00	1.60	.86
10.00	1.54	.81
15.00	1.45	.82
20.00	1.33	.82
25.00	1.19	.84
30.00	1.10	.85
35.00	1.19	.85
40.00	1.35	.80
45.00	1.49	1.00
50.00	1.57	1.12
55.00	1.59	1.20
60.00	1.52	1.20
65.00	1.45	1.16
70.00	1.51	1.12
75.00	1.66	1.25
80.00	1.70	1.49
85.00	1.51	1.57
90.00	1.32	1.55
95.00	2.45	2.46
00.00	5.16	5.25
05.00	8.53	8.63
10.00	9.71	11.20
15.00	7.10	12.76
20.00	4.10	14.48
25.00	6.18	19.45
30.00	13.75	26.21
35.00	24.40	32.35
40.00	34.07	37.70
45.00	41.54	42.50
50.00	43.88	46.70
55.00	43.08	50.81
60.00	42.51	54.52
65.00	44.08	58.41
70.00	41.28	62.28
75.00	42.50	64.04
80.00	45.40	67.66
85.00	44.41	73.16
90.00	43.98	73.51
95.00	44.01	88.84
00.00	45.08	88.64
05.00	46.48	80.75
10.00	53.26	91.08
15.00	56.21	86.62

Post Shock
#17

2 of 3

FREQ MHZ	VSWR	LOSS DB
20.00	63.46	91.41
25.00	61.34	85.66
30.00	65.79	89.50
35.00	67.38	97.96
40.00	65.33	83.04
45.00	60.46	89.79
50.00	67.74	90.80

POST SHOCK
#17
3 of 3


3DB
3DB
f_o
f_o-100
f_o+100
f_o-125
f_o+125
2DB MIN
45DB
MIN
S-13
MOLDED Filter
SPECIFICATIONS
DATE 03-26-80
S/N GF13
Post Shock
PRE Vib
2750

03/25/80
MOLDED 5-13 FILTER
GOLD PLATE
POST SHOCK 10

FREQ MHZ	VSNR	LOSS DB
00.00	69.02	80.83
05.00	65.54	84.40
10.00	70.90	77.00
15.00	68.21	72.06
20.00	63.10	71.30
25.00	61.49	68.09
30.00	56.08	66.06
35.00	55.16	62.09
40.00	56.47	59.64
45.00	56.77	56.60
50.00	57.14	53.19
55.00	58.01	49.97
60.00	54.10	46.43
65.00	48.71	42.94
70.00	42.30	39.04
75.00	37.90	34.01
80.00	31.95	30.43
85.00	24.75	25.44
90.00	18.11	19.94
95.00	10.63	13.04
00 00	5.06	7.43
05.00	2.16	3.30
10.00	1.33	2.20
15.00	1.46	2.21
20 00	1 76	2.26
25.00	2 03	2.19
30.00	2.11	1.93
35.00	1.99	1.35
40 00	1.70	1.19
45.00	1.38	1.05
50.00	1.13	1.02
55.00	1.14	1.01
60.00	1.29	1.02
65.00	1.39	1.03
70.00	1.41	.96
75 00	1.36	.92
80 00	1.27	.91
85 00	1.18	.86
90.00	1.16	.81
95.00	1 22	.78
00 00	1.30	.79
05 00	1.36	.83
10 00	1.39	.89
15.00	1.39	.93
20 00	1.37	1.02
25.00	1 32	1.00
30.00	1.27	.99
35.00	1.24	.99
40.00	1.23	1.02
45 00	1.26	1.02
50.00	1 30	1.04
55 00	1 37	1.09

Post Shock
#18

1 of 3

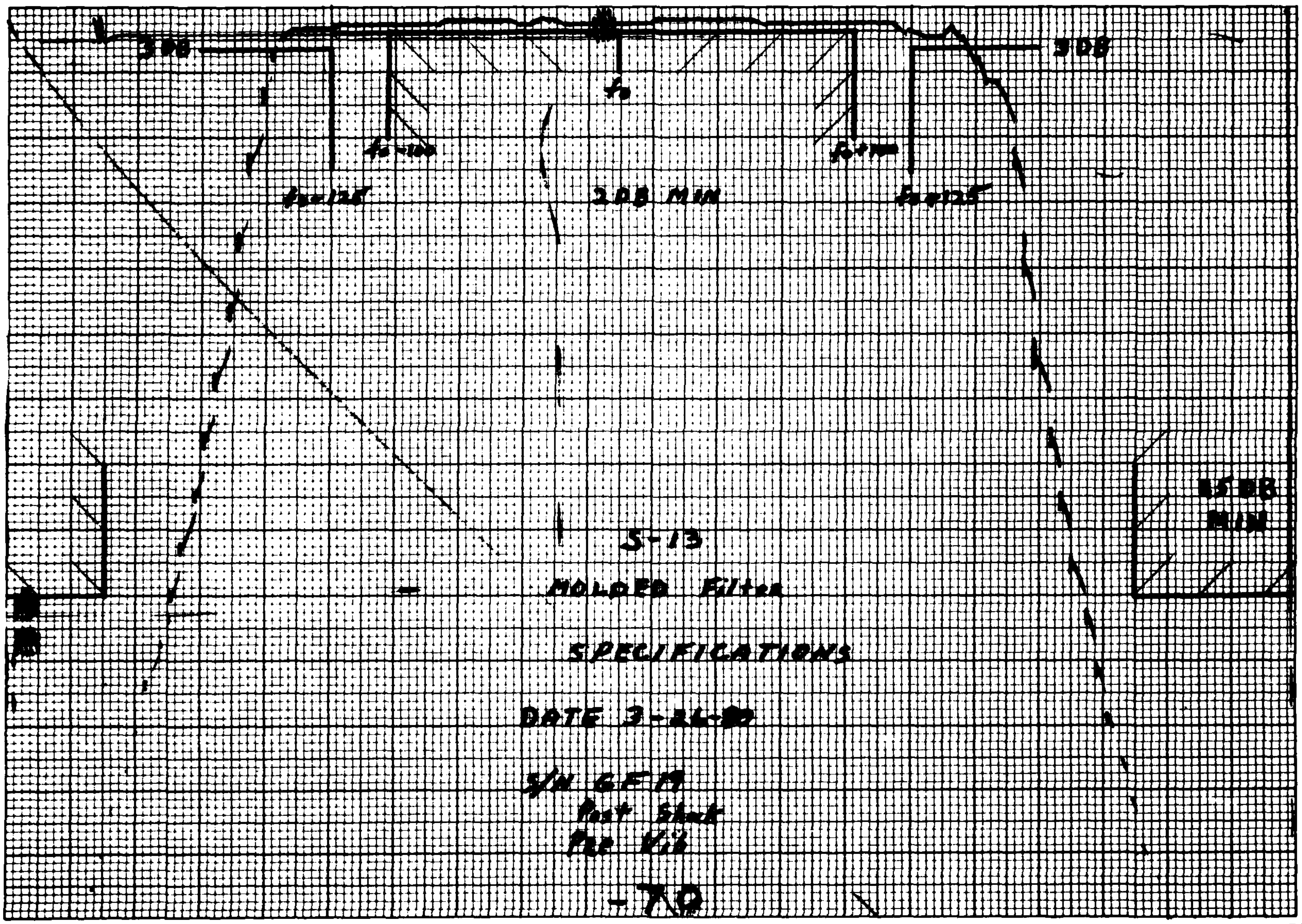
FREQ MHZ	VSWR	LOSS DB
60.00	1.41	1.09
65.00	1.44	1.11
70.00	1.46	1.06
75.00	1.44	1.03
80.00	1.40	.99
85.00	1.33	.93
90.00	1.25	.94
95.00	1.15	.92
00.00	1.07	.87
05.00	1.10	.83
10.00	1.20	.83
15.00	1.29	.90
20.00	1.38	1.03
25.00	1.44	1.12
30.00	1.50	1.23
35.00	1.54	1.27
40.00	1.61	1.24
45.00	1.72	1.26
50.00	1.85	1.35
55.00	1.95	1.51
60.00	2.00	1.64
65.00	1.92	1.72
70.00	1.74	1.66
75.00	1.47	1.48
80.00	1.28	1.33
85.00	1.41	1.47
90.00	1.73	1.81
95.00	2.00	2.17
00.00	2.10	2.22
05.00	2.23	2.24
10.00	2.76	2.86
15.00	3.53	4.03
20.00	3.40	4.41
25.00	3.82	5.62
30.00	15.15	14.01
35.00	33.04	22.06
40.00	46.14	28.62
45.00	52.63	34.20
50.00	50.46	39.20
55.00	50.60	43.67
60.00	48.52	47.79
65.00	49.33	51.93
70.00	50.10	55.71
75.00	58.04	59.17
80.00	55.34	62.69
85.00	55.10	66.04
90.00	53.10	69.01
95.00	50.00	74.30
00.00	52.65	77.19
05.00	56.58	78.75
10.00	64.98	87.36
15.00	71.99	83.04

POST SHOCK
#18

2 OF 3

FREQ MHZ	VSWR	LOSS DB
20.00	76.25	85.01
25.00	75.04	81.07
30.00	81.74	100.95
35.00	83.50	88.92
40.00	85.15	81.00
45.00	91.52	89.15
50.00	80.87	90.19

POST SHOCK
#18
3 OF 3



3DB
3DB
fo-125
fo-100
fo
fo+100
fo+125
2DB MIN
15DB MIN
S-13
MOLDED Filter
SPECIFICATIONS
DATE 3-26-80
S/N 6F19
Post Shock
Pre Vib
-70

2750

03/26/80
MOLDED S-13 FILTER
GOLD PLATE
POST SHOCK 19

FREQ MHZ	VSWR	LOSS DB
00.00	69.41	87.37
05.00	70.67	87.70
10.00	72.01	82.30
15.00	69.56	75.90
20.00	66.55	77.91
25.00	60.45	76.07
30.00	57.24	72.30
35.00	50.05	67.40
40.00	60.60	65.00
45.00	63.61	61.76
50.00	61.86	50.42
55.00	65.09	55.47
60.00	63.70	52.00
65.00	57.95	40.72
70.00	52.43	45.13
75.00	49.00	41.57
80.00	42.70	37.63
85.00	35.05	33.39
90.00	28.75	28.77
95.00	21.03	23.70
00.00	13.25	18.22
05.00	7.89	12.23
10.00	4.41	6.99
15.00	2.77	3.50
20.00	1.87	1.95
25.00	1.26	1.43
30.00	1.20	1.35
35.00	1.47	1.33
40.00	1.62	1.17
45.00	1.56	1.00
50.00	1.30	.89
55.00	1.16	.84
60.00	1.07	.86
65.00	1.25	.93
70.00	1.43	.91
75.00	1.57	.87
80.00	1.64	.86
85.00	1.66	.84
90.00	1.64	.79
95.00	1.50	.77
00.00	1.52	.74
05.00	1.45	.76
10.00	1.30	.79
15.00	1.31	.81
20.00	1.24	.84
25.00	1.19	.83
30.00	1.17	.79
35.00	1.20	.78
40.00	1.26	.83
45.00	1.33	.86
50.00	1.40	.90
55.00	1.46	.97

Post Shock
#19

1 of 3

FREQ MHZ	VSWR	LOSS DB
60.00	1.48	1.00
65.00	1.47	.98
70.00	1.42	.92
75.00	1.34	.82
80.00	1.25	.77
85.00	1.15	.71
90.00	1.07	.69
95.00	1.11	.74
00.00	1.22	.75
05.00	1.33	.75
10.00	1.42	.73
15.00	1.48	.74
20.00	1.48	.79
25.00	1.43	.83
30.00	1.35	.87
35.00	1.26	.91
40.00	1.23	.88
45.00	1.29	.85
50.00	1.41	.88
55.00	1.50	.97
60.00	1.53	1.03
65.00	1.46	1.07
70.00	1.30	1.04
75.00	1.18	1.02
80.00	1.38	1.06
85.00	1.75	1.38
90.00	2.18	1.79
95.00	2.22	2.07
00.00	1.93	1.94
05.00	1.49	1.53
10.00	2.01	1.99
15.00	3.69	3.75
20.00	5.42	5.20
25.00	6.35	5.62
30.00	14.70	10.67
35.00	35.54	19.26
40.00	50.86	26.32
45.00	52.75	32.28
50.00	52.57	37.45
55.00	51.52	42.17
60.00	50.47	46.34
65.00	49.29	50.40
70.00	48.46	54.37
75.00	48.38	57.71
80.00	53.42	60.79
85.00	53.26	64.20
90.00	51.58	66.86
95.00	48.36	72.43
00.00	50.96	76.42
05.00	55.29	75.72
10.00	61.57	101.85
15.00	60.11	84.10

Post Shock
#19
2 of 3

FREQ MHZ	VSWR	LOSS DB
20.00	72.00	01.76
25.00	75.13	02.35
30.00	76.03	06.06
35.00	01.70	07.26
40.00	04.03	03.35
45.00	91.00	00.91
50.00	03.37	90.96

POST SHOCK
#19

3 of 3

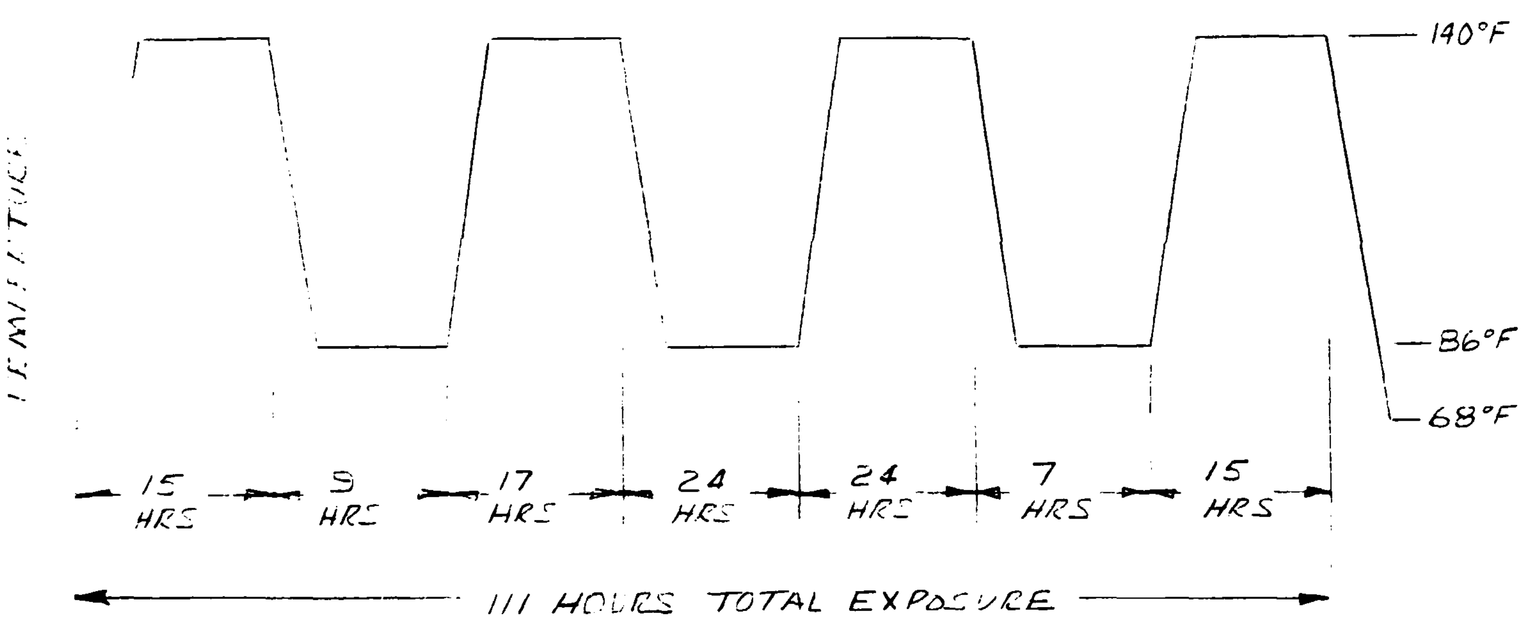
ANNEX D

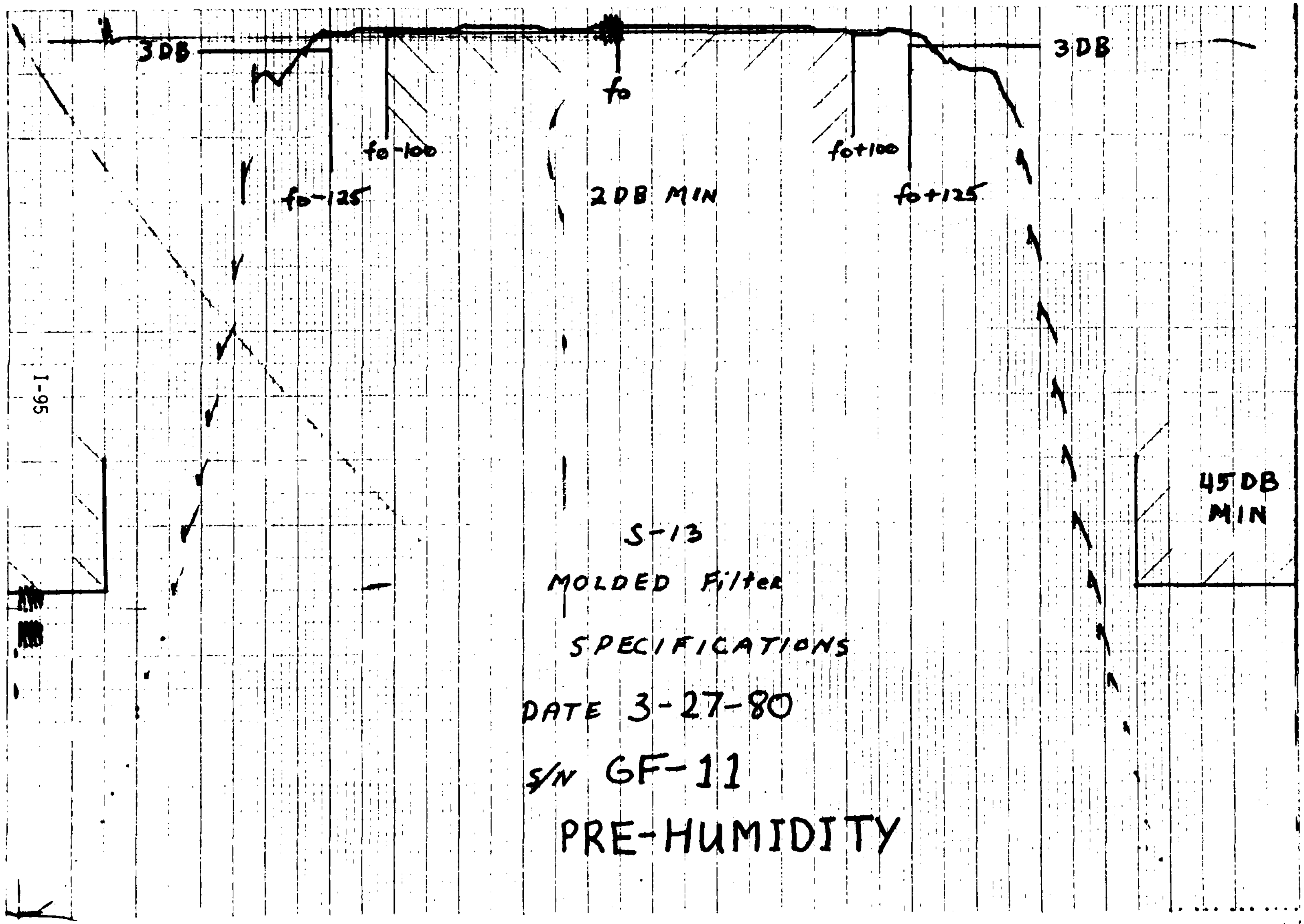
HUMIDITY DATA

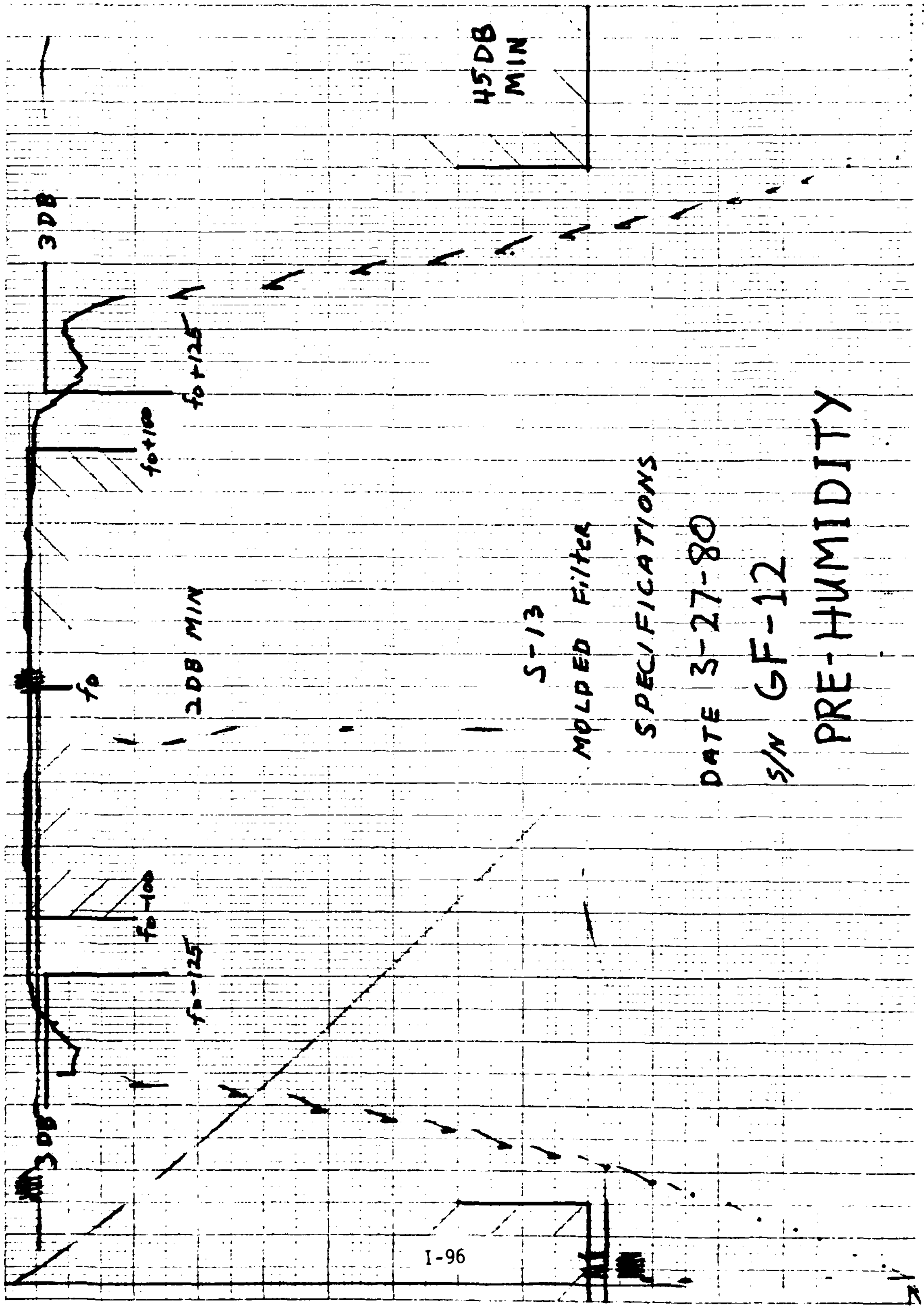
GENERAL DYNAMICS
Pomona Division

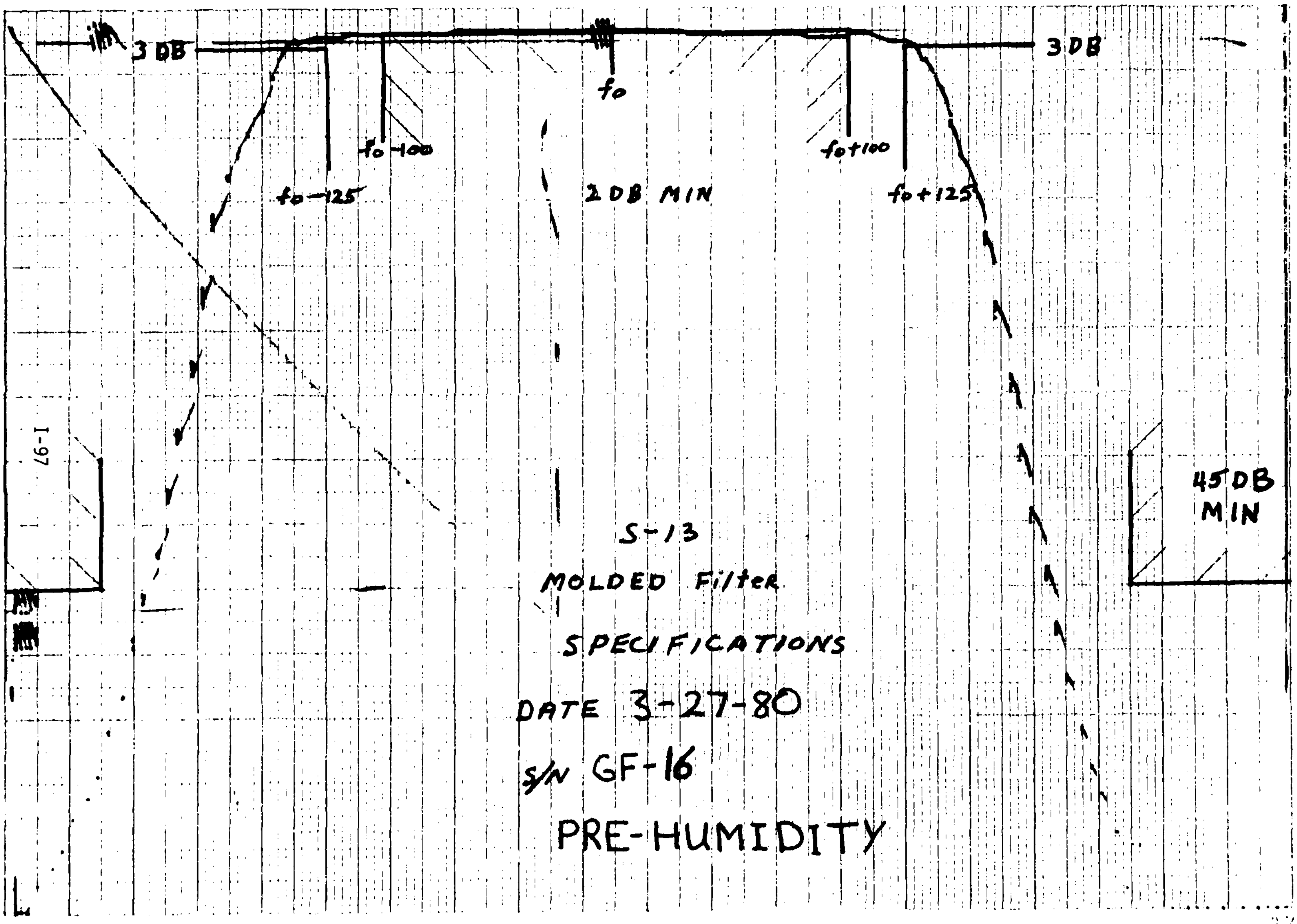
HUMIDITY CYCLING PROFILE

CONSTANT 95% R.H




3DB
3DB
fo
fo-100
fo+100
fo-125
fo+125
2DB MIN
45DB MIN
S-13
MOLDED Filter
SPECIFICATIONS
DATE 3-27-80
S/N GF-11
PRE-HUMIDITY


45DB MIN
3DB
fo+125
fo+100
2DB MIN
fo
S-13
MOLDED Filter
SPECIFICATIONS
DATE 3-27-80
S/N GF-12
PRE-HUMIDITY
fo-100
fo-125
3DB


3 DB
3 DB
fo
fo-100
fo-125
fo+100
fo+125
2 DB MIN
45 DB MIN
S-13
MOLDED Filter
SPECIFICATIONS
DATE 3-27-80
S/N GF-16
PRE-HUMIDITY

03/27/80 SRB
1856/ALLEN

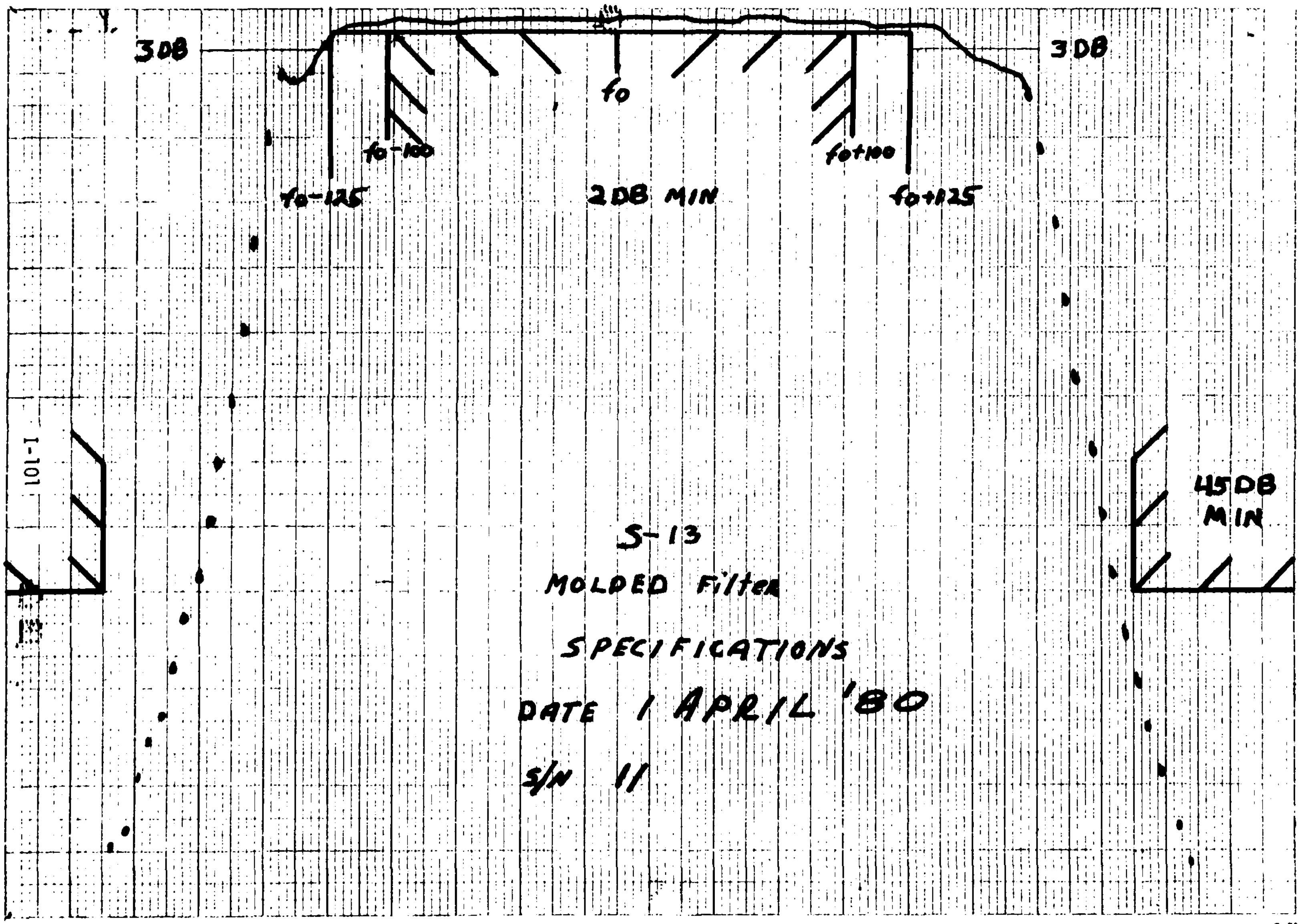
S-13 FILTERS
AMBIENT

PRE HUMIDITY

FREQ MHZ	VSWR GF-11	LOSS DB	VSWR GF-12	LOSS DB	VSWR GF-16	LOSS DB
00.00	$$$$$$$$$$$	83.20	$$$$$$$$$$$	73.83	$$$$$$$$$$$	77.00
05.00	$$$$$$$$$$$	78.37	$$$$$$$$$$$	72.21	$$$$$$$$$$$	75.03
10.00	$$$$$$$$$$$	71.98	$$$$$$$$$$$	67.99	$$$$$$$$$$$	69.05
15.00	$$$$$$$$$$$	71.09	$$$$$$$$$$$	65.76	$$$$$$$$$$$	67.94
20.00	$$$$$$$$$$$	69.10	$$$$$$$$$$$	62.96	$$$$$$$$$$$	66.49
25.00	$$$$$$$$$$$	67.90	$$$$$$$$$$$	61.15	$$$$$$$$$$$	65.22
30.00	$$$$$$$$$$$	65.91	$$$$$$$$$$$	58.45	$$$$$$$$$$$	62.67
35.00	$$$$$$$$$$$	64.54	$$$$$$$$$$$	55.01	$$$$$$$$$$$	61.20
40.00	$$$$$$$$$$$	63.10	$$$$$$$$$$$	53.25	$$$$$$$$$$$	59.30
45.00	$$$$$$$$$$$	60.85	$$$$$$$$$$$	50.00	$$$$$$$$$$$	56.21
50.00	$$$$$$$$$$$	58.61	$$$$$$$$$$$	46.72	$$$$$$$$$$$	53.27
55.00	$$$$$$$$$$$	54.82	$$$$$$$$$$$	42.91	$$$$$$$$$$$	49.41
60.00	$$$$$$$$$$$	51.86	$$$$$$$$$$$	38.94	$$$$$$$$$$$	45.00
65.00	$$$$$$$$$$$	48.73	$$$$$$$$$$$	34.65	$$$$$$$$$$$	42.10
70.00	$$$$$$$$$$$	45.15	$$$$$$$$$$$	29.89	$$$$$$$$$$$	37.91
75.00	$$$$$$$$$$$	41.14	$$$$$$$$$$$	24.42	$$$$$$$$$$$	33.14
80.00	$$$$$$$$$$$	36.85	47.75	18.10	62.10	27.92
85.00	$$$$$$$$$$$	32.10	8.99	10.65	17.64	22.21
90.00	$$$$$$$$$$$	26.91	1.55	4.92	7.13	16.50
95.00	$$$$$$$$$$$	20.70	3.29	4.80	5.30	12.60
00.00	21.00	13.10	5.33	4.90	8.16	10.73
05.00	2.57	5.21	4.93	4.34	10.61	9.20
10.00	3.50	4.65	3.61	3.30	8.22	7.12
15.00	6.14	5.32	2.54	2.43	4.60	4.75
20.00	5.19	4.57	1.86	1.81	2.27	2.04
25.00	3.25	3.24	1.52	1.49	1.30	1.92
30.00	1.82	2.07	1.39	1.33	1.49	1.69
35.00	1.12	1.51	1.39	1.29	1.76	1.63
40.00	1.29	1.41	1.47	1.29	1.72	1.53
45.00	1.45	1.30	1.57	1.30	1.51	1.39
50.00	1.40	1.32	1.64	1.29	1.34	1.26
55.00	1.22	1.24	1.64	1.27	1.36	1.23
60.00	1.10	1.17	1.50	1.24	1.49	1.26
65.00	1.24	1.19	1.47	1.21	1.60	1.33
70.00	1.41	1.22	1.34	1.14	1.65	1.34
75.00	1.54	1.27	1.23	1.12	1.61	1.33
80.00	1.57	1.27	1.16	1.09	1.51	1.20
85.00	1.52	1.22	1.15	1.05	1.39	1.19
90.00	1.48	1.17	1.10	1.09	1.20	1.16
95.00	1.27	1.08	1.22	1.03	1.20	1.09
00.00	1.14	1.03	1.26	1.03	1.16	1.06
05.00	1.05	1.04	1.30	1.06	1.17	1.07
10.00	1.11	1.02	1.35	1.07	1.21	1.06
15.00	1.22	1.03	1.40	1.08	1.26	1.07
20.00	1.33	1.01	1.46	1.09	1.31	1.04
25.00	1.43	1.05	1.54	1.12	1.34	1.07
30.00	1.52	1.10	1.61	1.15	1.36	1.06
35.00	1.59	1.12	1.68	1.15	1.38	1.09
40.00	1.63	1.14	1.76	1.18	1.39	1.09
45.00	1.64	1.14	1.79	1.18	1.39	1.08
50.00	1.68	1.09	1.80	1.18	1.38	1.07
55.00	1.52	1.05	1.77	1.19	1.35	1.08

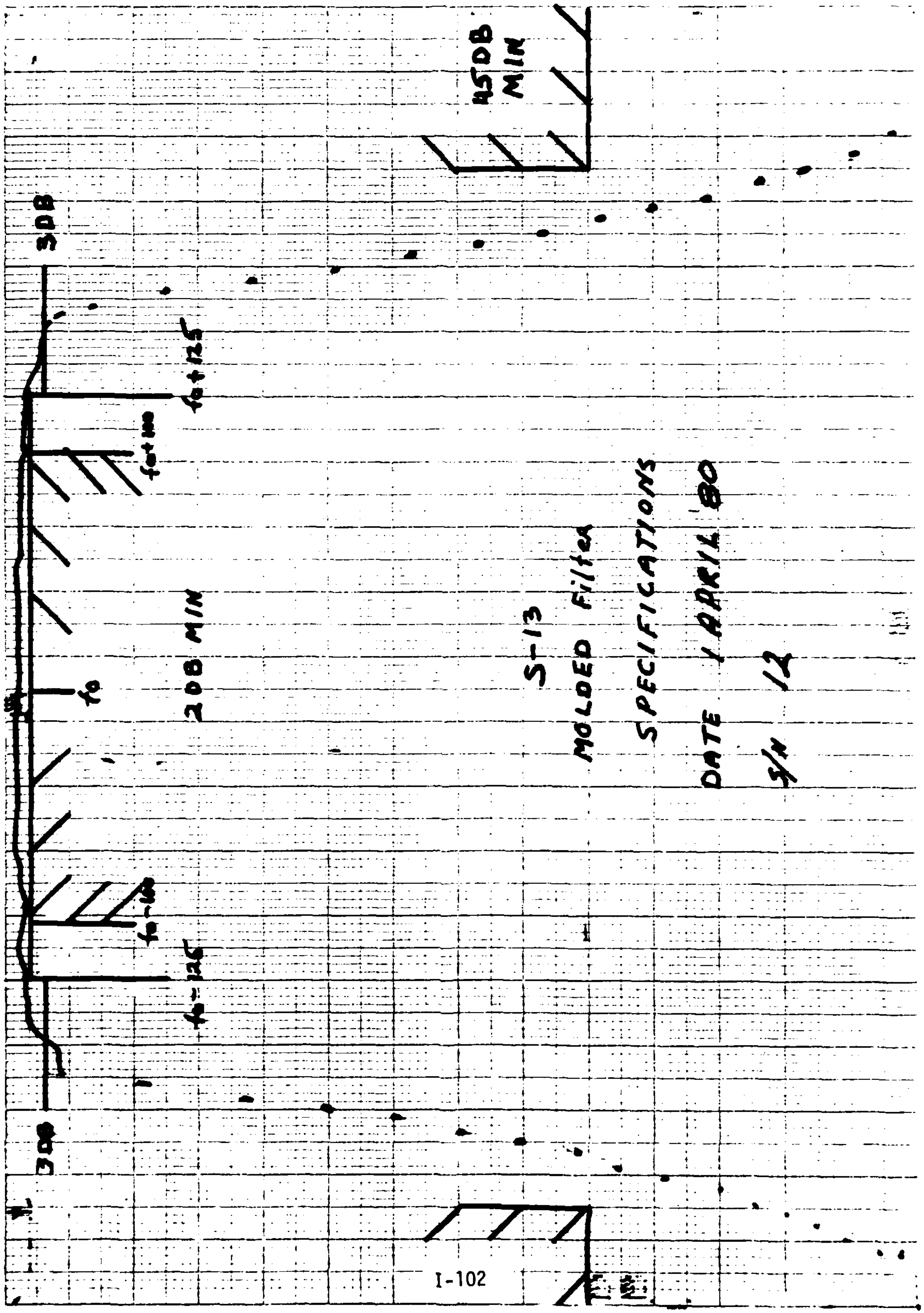
FREQ MHZ	VSNR GF-11 (11)	LOSS DB	VSNR GF-12 (12)	LOSS DB	VSNR GF-16 (16)	LOSS DB
60.00	1.41	1.03	1.72	1.15	1.38	1.04
65.00	1.30	1.00	1.67	1.17	1.23	1.01
70.00	1.21	.97	1.61	1.15	1.16	1.02
75.00	1.20	.97	1.55	1.12	1.09	1.02
80.00	1.27	1.01	1.48	1.09	1.09	1.02
85.00	1.36	1.04	1.39	1.04	1.16	1.05
90.00	1.43	1.07	1.32	1.00	1.27	1.08
95.00	1.44	1.08	1.29	1.01	1.40	1.14
00.00	1.40	1.02	1.32	1.02	1.51	1.17
05.00	1.33	1.00	1.39	1.07	1.61	1.22
10.00	1.25	.99	1.43	1.12	1.64	1.26
15.00	1.20	.95	1.41	1.10	1.61	1.24
20.00	1.20	.97	1.30	1.09	1.48	1.20
25.00	1.21	1.00	1.14	1.12	1.29	1.17
30.00	1.20	.99	1.13	1.10	1.16	1.13
35.00	1.17	1.03	1.30	1.22	1.26	1.19
40.00	1.19	1.09	1.66	1.40	1.47	1.32
45.00	1.31	1.15	1.91	1.53	1.67	1.40
50.00	1.49	1.24	1.96	1.59	1.76	1.49
55.00	1.68	1.29	1.75	1.52	1.68	1.47
60.00	1.83	1.37	1.35	1.41	1.45	1.42
65.00	1.84	1.43	1.21	1.42	1.20	1.36
70.00	1.70	1.42	1.97	1.84	1.83	1.37
75.00	1.46	1.34	3.37	2.74	1.40	1.49
80.00	1.29	1.30	5.40	3.06	1.62	1.64
85.00	1.53	1.43	7.53	4.73	1.45	1.77
90.00	2.16	1.89	6.34	5.23	1.16	2.04
95.00	3.06	2.57	7.09	5.10	2.11	3.10
00.00	4.11	3.33	4.55	4.60	4.80	5.27
05.00	4.05	3.91	2.66	3.89	11.40	8.00
10.00	4.96	4.20	2.10	3.97	29.45	10.65
15.00	4.28	4.26	3.01	6.25	130.63	13.19
20.00	3.51	4.50	12.16	12.15	$$$$$$$$$$	16.91
25.00	3.71	6.26	57.76	19.63	$$$$$$$$$$	22.16
30.00	7.34	10.41	$$$$$$$$$$	26.33	$$$$$$$$$$	27.92
35.00	20.46	16.45	$$$$$$$$$$	32.31	$$$$$$$$$$	33.43
40.00	91.35	22.63	$$$$$$$$$$	37.61	$$$$$$$$$$	38.40
45.00	$$$$$$$$$$	28.47	$$$$$$$$$$	42.62	$$$$$$$$$$	43.11
50.00	$$$$$$$$$$	33.89	$$$$$$$$$$	46.89	$$$$$$$$$$	47.35
55.00	$$$$$$$$$$	30.92	$$$$$$$$$$	51.37	$$$$$$$$$$	51.61
60.00	$$$$$$$$$$	43.71	$$$$$$$$$$	55.53	$$$$$$$$$$	55.64
65.00	$$$$$$$$$$	47.80	$$$$$$$$$$	58.55	$$$$$$$$$$	58.62
70.00	$$$$$$$$$$	51.55	$$$$$$$$$$	61.50	$$$$$$$$$$	60.89
75.00	$$$$$$$$$$	55.33	$$$$$$$$$$	64.07	$$$$$$$$$$	63.89
80.00	$$$$$$$$$$	59.13	$$$$$$$$$$	68.66	$$$$$$$$$$	66.27
85.00	$$$$$$$$$$	62.93	$$$$$$$$$$	72.73	$$$$$$$$$$	72.04
90.00	$$$$$$$$$$	65.94	$$$$$$$$$$	76.19	$$$$$$$$$$	77.50
95.00	$$$$$$$$$$	70.55	$$$$$$$$$$	82.09	$$$$$$$$$$	80.51
00.00	$$$$$$$$$$	72.79	$$$$$$$$$$	77.94	$$$$$$$$$$	80.19
05.00	$$$$$$$$$$	78.23	$$$$$$$$$$	82.00	$$$$$$$$$$	81.93
10.00	$$$$$$$$$$	79.50	$$$$$$$$$$	84.55	$$$$$$$$$$	82.87
15.00	$$$$$$$$$$	83.22	$$$$$$$$$$	83.48	$$$$$$$$$$	85.45

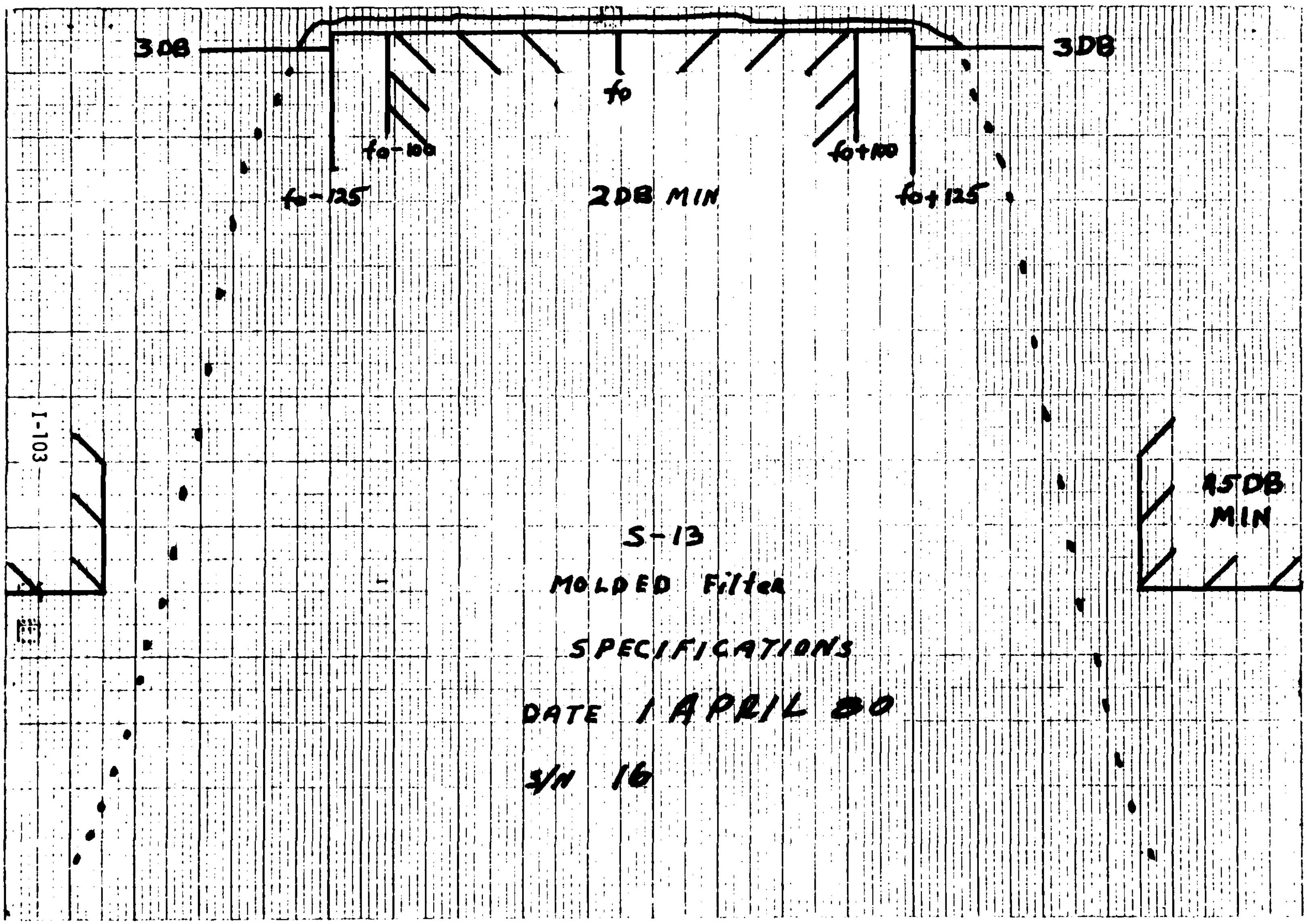
FREQ MHZ	VSWR GF-11	LOSS DB	VSWR GF-12	LOSS DB	VSWR GF-16	LOSS DB
20.00	$$$$$$$$$$$	83.01	$$$$$$$$$$$	81.52	$$$$$$$$$$$	80.54
25.00	$$$$$$$$$$$	82.46	$$$$$$$$$$$	78.24	$$$$$$$$$$$	79.06
30.00	$$$$$$$$$$$	83.73	$$$$$$$$$$$	79.60	$$$$$$$$$$$	81.40
35.00	$$$$$$$$$$$	80.39	$$$$$$$$$$$	88.48	$$$$$$$$$$$	84.50
40.00	$$$$$$$$$$$	80.81	$$$$$$$$$$$	84.85	$$$$$$$$$$$	81.45
45.00	$$$$$$$$$$$	86.16	$$$$$$$$$$$	85.60	$$$$$$$$$$$	81.66
50.00	$$$$$$$$$$$	91.63	$$$$$$$$$$$	86.82	$$$$$$$$$$$	81.06



POST HUMIDITY

2750


S-13
MOLDED Filter
SPECIFICATIONS
DATE 1 APRIL 80
S/N 12
POST HUMIDITY
3DB
45DB MIN
fo+125
fo+100
fo
2DB MIN
fo-100
fo-125
3DB



POST HUMIDITY

2750

MOLDED S-15 FILTER
GOLD PLATE
POST HUMIDITY GF11

FREQ MHZ	VSWR	LOSS DB
00.00	130.56	96.47
05.00	121.95	79.63
10.00	105.84	76.25
15.00	102.98	80.66
20.00	109.26	75.16
25.00	95.53	73.99
30.00	93.56	71.02
35.00	96.42	68.16
40.00	90.23	65.87
45.00	87.32	64.63
50.00	79.39	63.53
55.00	73.56	59.66
60.00	74.56	56.86
65.00	73.59	54.78
70.00	63.13	51.13
75.00	56.72	47.65
80.00	49.80	44.87
85.00	46.42	40.30
90.00	40.11	35.97
95.00	34.67	31.13
00.00	26.57	25.58
05.00	18.35	19.04
10.00	7.27	10.75
15.00	2.27	4.85
20.00	4.93	5.83
25.00	5.62	5.90
30.00	4.31	4.75
35.00	2.71	3.22
40.00	1.60	2.17
45.00	1.07	1.65
50.00	1.25	1.54
55.00	1.34	1.49
60.00	1.27	1.42
65.00	1.11	1.24
70.00	1.06	1.[illegible]
75.00	1.22	1.[illegible]
80.00	1.26	1.[illegible]
85.00	1.44	1.41
90.00	1.43	1.39
95.00	1.36	1.2[illegible]
00.00	1.25	1.20
05.00	1.12	1.15
10.00	1.05	1.[illegible]
15.00	1.14	1.16
20.00	1.25	1.17
25.00	1.34	1.15
30.00	1.41	1.1[illegible]
35.00	1.45	1.2[illegible]
40.00	1.47	1.2[illegible]
45.00	1.45	1.20
50.00	1.42	1.15
55.00	1.36	1.14

Post Humidity
#11

1 of 3

S/N 11

POST HUMIDITY

FREQ MHZ	VSWR	LOSS DB
60.00	1.30	1.10
65.00	1.25	1.08
70.00	1.21	1.09
75.00	1.20	1.07
80.00	1.22	1.07
85.00	1.26	1.08
90.00	1.31	1.09
95.00	1.34	1.13
00.00	1.36	1.12
05.00	1.34	1.10
10.00	1.31	1.10
15.00	1.25	1.06
20.00	1.20	1.04
25.00	1.17	1.07
30.00	1.16	1.04
35.00	1.18	1.10
40.00	1.18	1.16
45.00	1.16	1.15
50.00	1.13	1.15
55.00	1.13	1.19
60.00	1.21	1.23
65.00	1.33	1.30
70.00	1.45	1.38
75.00	1.52	1.44
80.00	1.48	1.45
85.00	1.31	1.40
90.00	1.06	1.42
95.00	1.30	1.59
00.00	1.80	2.10
05.00	2.68	2.82
10.00	3.58	3.65
15.00	4.10	4.31
20.00	4.25	4.65
25.00	3.83	4.87
30.00	3.36	5.39
35.00	3.49	7.14
40.00	5.18	10.95
45.00	9.13	16.63
50.00	14.00	22.60
55.00	22.35	28.42
60.00	30.11	33.83
65.00	38.06	38.67
70.00	47.84	43.40
75.00	54.23	47.38
80.00	59.02	51.92
85.00	69.01	55.46
90.00	68.61	59.02
95.00	76.65	62.30
00.00	84.50	65.19
05.00	88.27	66.89
10.00	89.19	70.31
15.00	85.38	76.29

2 OF 3

FREQ MHZ	VSWR	LOSS DB
20.00	80.55	72.63
25.00	89.12	78.10
30.00	86.02	90.57
35.00	80.79	89.16
40.00	81.06	85.30
45.00	72.26	79.34
50.00	74.05	77.57

S/N 11

POST HUMIDITY

3 of 3

04/01/80
MOLDED S-13 FILTER
GOLD PLATE
POST HUMIDITY GF16

FREQ MHZ	VSWR	LOSS DB
00.00	118.85	81.25
05.00	96.98	78.21
10.00	98.87	76.60
15.00	82.21	76.59
20.00	81.92	71.97
25.00	75.49	69.89
30.00	69.16	65.69
35.00	71.38	63.95
40.00	68.42	61.75
45.00	62.54	59.43
50.00	53.86	56.57
55.00	46.41	53.04
60.00	41.52	49.71
65.00	36.86	46.41
70.00	29.53	42.50
75.00	24.84	38.26
80.00	18.86	33.71
85.00	13.32	28.62
90.00	8.45	23.01
95.00	4.84	17.51
00.00	3.80	13.36
05.00	5.08	11.14
10.00	6.04	9.51
15.00	5.30	7.50
20.00	3.58	5.17
25.00	2.09	3.25
30.00	1.26	2.19
35.00	1.20	1.84
40.00	1.34	1.73
45.00	1.30	1.58
50.00	1.16	1.49
55.00	1.08	1.44
60.00	1.22	1.43
65.00	1.36	1.48
70.00	1.45	1.53
75.00	1.48	1.55
80.00	1.44	1.47
85.00	1.39	1.42
90.00	1.35	1.38
95.00	1.36	1.32
00.00	1.42	1.31
05.00	1.47	1.34
10.00	1.51	1.33
15.00	1.51	1.31
20.00	1.47	1.29
25.00	1.41	1.25
30.00	1.34	1.23
35.00	1.28	1.21
40.00	1.25	1.21
45.00	1.25	1.20
50.00	1.28	1.19
55.00	1.31	1.23

Post Humidity
#16
1 of 3

FREQ MHZ	VSWR	LOSS DB
60.00	1.33	1.21
65.00	1.33	1.20
70.00	1.30	1.19
75.00	1.26	1.17
80.00	1.19	1.14
85.00	1.10	1.16
90.00	1.61	1.15
95.00	1.10	1.15
00.00	1.21	1.20
05.00	1.34	1.22
10.00	1.46	1.29
15.00	1.55	1.34
20.00	1.62	1.[illegible]
25.00	1.64	1.42
30.00	1.61	1.38
35.00	1.57	1.37
40.00	1.53	1.42
45.00	1.54	1.45
50.00	1.57	1.50
55.00	1.60	1.54
60.00	1.58	1.56
65.00	1.49	1.54
70.00	1.34	1.50
75.00	1.25	1.49
80.00	1.30	1.57
85.00	1.42	1.78
90.00	1.41	1.90
95.00	1.26	2.14
00.00	1.62	2.87
05.00	3.01	4.57
10.00	5.76	6.98
15.00	9.29	9.43
20.00	15.57	11.82
25.00	24.11	14.29
30.00	37.36	19.87
35.00	53.73	25.71
40.00	68.54	31.[illegible]
45.00	86.46	36.5[illegible]
50.00	94.09	41.[illegible]
55.00	102.51	45.95
60.00	97.12	50.11
65.00	105.86	53.82
70.00	109.14	57.4[illegible]
75.00	115.83	61.26
80.00	112.37	64.79
85.00	127.59	67.14
90.00	114.48	69.17
95.00	119.89	72.55
00.00	117.49	71.[illegible]
05.00	105.47	70.93
10.00	120.92	73.[illegible]
15.00	100.97	79.47

POST HUMIDITY
#16

2 OF 3

FREQ MHZ	VSNR	LOSS DB
20.00	101.61	73.95
25.00	101.11	78.95
30.00	100.08	85.10
35.00	87.27	85.56
40.00	83.30	83.74
45.00	76.78	77.55
50.00	77.81	78.56

Post Humidity
#16
3 of 3

APPENDIX J

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX J

GENERAL ELECTRIC INJECTION MOLDED RESIN SPECIFICATIONS - VALOX 420 SEO

The VALOX® 400 Family

VALOX 400 series — The highest heat resistance plus a complete range of glass reinforcement from 15% to 40% and UL94 V-0.

Property	Units	Test Method	VALOX 420 (30% Glass Reinforced)	VALOX DR-51 (15% Glass Reinforced)	VALOX 414 (40% Glass Reinforced)	VALOX 420-SEO (30% Glass Reinforced and UL 94V-0 Recognized)	VALOX DR-48 (15% Glass Reinforced and UL 94V-0 Recognized)	VALOX 459 (30% Glass Reinforced and UL 94V-0 Recognized)
Specific Gravity, 73°F		D792	1.53	1.41	1.60	1.62	1.53	1.70
Specific Volume	cu. in./lb.		18.2	19.7	17.3	17.2	18.7	16.3
Water Absorption, 73°F	%	D570						
24 hours			0.06	0.07	0.06	0.07	0.07	0.07
Equilibrium			0.26	0.30	0.36	0.25	0.30	0.25
Mold Shrinkage	in./in. x 10^{-3}							
Flow Direction			4-6**	6-8***	3-5**	4-6**	6-8***	4-6**
Cross Flow Direction			6-8	8-10	5-7	6-8	8-10	6-8
Tensile Strength	psi	D638	17,300	13,000	19,000	17,000	13,000	18,000
Elongation at Break	%	D1708	3	5	3	3	5	3
Flexural Strength	psi	D790	27,500	20,000	30,000	27,000	21,000	27,000
Flexural Modulus	psi	D790	1,100,000	670,000	1,300,000	1,100,000	730,000	1,200,000
Compressive Strength, 10% Def	psi	D695	18,000	15,000	18,000	18,000	15,000	18,000
Shear Strength	psi	D732	8,900	8,000	8,600	9,000	8,000	9,000
Izod Impact Strength	ft. lb./in.	D256						
Notched			1.8	1.1	2.2	1.3	1.0	1.5
Unnotched			15.0	10.0	18.0	13.0	10.0	11.0
Gardner Impact	ft. lbs.	Falling Dart	—	—	—	—	—	—
Chemical Resistance			Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Coefficient of Friction,		D1894						
Self			0.16	0.17	—	0.16	0.17	0.16
Metal			0.14	0.14	—	0.14	0.14	0.14
Rockwell Hardness, R Scale		D785	118	118	117	119	118	119
Tabor Abrasion, CS-17 wheel, 1000 gm load	mg/1000 cycles	D1044	19.0	12.0	26.0	22.0	17.0	19.0
Heat Deflection Temp	°F	D648						
66 psi			420	410	420	420	410	420
264 psi			405	375	390	400	360	400
Coefficient of Thermal Expansion Range: -30°C to +30°C (-22°F to +86°F)	in./in./°F x 10^{-5}	D696						
Mold-direction			1.5	2.5	1.5	1.4	2.2	1.4
Cross mold-direction			4.3	4.1	5.0	4.0	4.0	4.0
Flammability†	in./min.	D635	1.3	1.3	—	0	0	0
@ 0.028"		UL94	94HB	94HB/0.058"	—	94V-0	94V-0	94V-0
Volume Resistivity	ohm cm x 10^{16}	D257	3.2	3.3	—	3.4	3.6	3.4
Dielectric Strength, 73°F DAM‡	volts/mil	D149						
short time, 1/16"			630	590	—	610	650	600
short time, 1/8"			475	500	552	490	480	470
150°F, 50% R.H			470	410	520	420	400	500
250°F, 50% R.H			450	410	520	415	350	500
Dielectric Constant		D150						
100 HZ			3.8	3.6	3.8	3.8	3.6	3.8
10^6 HZ			3.7	3.4	3.7	3.7	3.4	3.7
Dissipation Factor		D150						
100 HZ			0.002	0.002	0.002	0.002	0.002	0.002
10^6 HZ			0.02	0.02	0.02	0.02	0.02	0.02
Arc Resistance	sec.	D495	146	129	—	28	28	123
High Voltage-Arc Tracking Rate, 1/16"	in./min.	UL 746A	0.9	0.9	—	11.6	21.0	7.7
High Ampere Arc Ignition, 1/16"	No. of arcs	UL 746A	112	112	—	200+	200+	71
Comparative Track Index (CTI) 1/8"	Volts	UL 746A	600+	355	—	185	235	270
Hot Wire Ignition, 1/16"	sec	UL 746A	68	16	—	34	20	30
U.L. Temperature Index	°C @ 1/16	UL 746B						
Elec. Properties			140	130	—	130	120	130
Mech. Properties w/w/o Impact			140/140	130/140	—	130/140	120/140	130/140

† This rating is not intended to reflect hazards presented by this or any other material under actual fire conditions.
* In thin walls (0.025" to 0.045") it is suggested to use 6-10 mils in shrinkage.
** In thin walls (0.025" to 0.050") it is suggested to use 3-4 mils in shrinkage.
*** In thin walls it is suggested to use 4-6 mils in shrinkage.
‡ Dry As Molded

The VALOX® 300 Family

VALOX 300 series — A complete line of unreinforced thermoplastic polyester. All are designed for fast, easy processing, surface gloss and superior lubricity. And the line includes a UL94 V-0 grade along with the only super high impact PBT available today.

Property	Units	Test Method	VALOX 325 (Unreinforced)	VALOX 310-SEO (Unreinforced and UL 94V-0 Recognized)	VALOX 326 Unreinforced Impact Modified PBT	VALOX 340/341 Unreinforced High Impact PBT
Specific Gravity, 73°F		D792	1.31	1.41	1.28	1.25/1.26
Specific Volume	cu. in./lb.		21.2	19.7	21.6	22.3/22.1
Water Absorption, 73°F	%	D570				
24 hours			0.08	0.08	0.08	0.08/0.08
Equilibrium			0.34	0.38	0.50	—
Mold Shrinkage	in./in. x 10^{-3}		17-23*	17-23**	20-21***	20-21/17-18
Tensile Strength	psi	D638	7,500	8,500	7,000	6,500/6,500
Elongation at Break	%	D1708	300	80	300	175/175
Flexural Strength	psi	D790	12,000	14,700	12,000	10,500/11,000
Flexural Modulus	psi	D790	340,000	380,000	310,000	275,000/290,000
Compressive Strength,	psi	D695				
10% Def			13,000	14,500	—	—
Shear Strength	psi	D732	7,700	7,700	7,100	5300/5300
Izod Impact Strength	ft. lb./in.	D256				
Notched			1.0	0.7	1.5	16/12
Unnotched			NB	NB	NB	NB/NB
Gardner Impact	ft. lbs.	Falling Dart	30	25	22	40/40
Chemical Resistance			Excellent	Excellent	Excellent	Excellent
Coefficient of Friction,		D1894				
Self			0.17	0.16	0.18	0.16/0.17
Metal			0.13	0.14	0.13	0.18/0.15
Rockwell Hardness, R Scale		D785	117	120	114	113/113
Tabor Abrasion, CS-17	mg/1000 cycles	D1044				
wheel, 1000 gm load			9.0	14.0	16.0	37.0/22.0
Heat Deflection Temp.	°F	D648				
66 psi			310	325	—	250/260
264 psi			130	160	130	160/135
Coefficient of Thermal						
Expansion	in./in./°F x 10^{-5}	D696				
Range: -30°C to +30°C						
(−22°F to +86°F)						
Mold-direction			4.0	3.6	—	6.0/5.4
Cross mold-direction			4.1	3.6	—	6.5/5.7
Flammability†	in./min.	D635	1.0	0	—	—
@ 0.028"		UL94	94HB	94V-0/0.028"	—	94HB/94HB
Volume Resistivity	ohm. cm x 10^{16}	D257	4.0	4.0	1.4	0.38/0.13
Dielectric Strength, 73°F, DAM ‡	volts/mil	D149				
short time, 1/16"			590	560	517	570/590
short time, 1/8"			400	470	380	350/380
150°F, 50% R.H.			400	375	390	400/380
250°F, 50% R.H.			400	340	420	420/400
Dielectric Constant		D150				
100 HZ			3.3	3.3	3.1	3.3/3.2
10^6 HZ			3.1	3.1	3.0	3.1/3.0
Dissipation Factor		D150				
100 HZ			0.002	0.003	0.005	0.004/0.002
10^6 HZ			0.02	0.02	0.02	0.03/0.02
Arc Resistance	sec	D495	184	63	135	146/129
High Voltage-Arc						
Tracking Rate, 1/16"	in./min.	UL 746A	1.0	21.0	—	0.3/1.0
High Ampere Arc						
Ignition, 1/16"	No. of arcs	UL 746A	200+	200+	—	200+/200+
Comparative Track						
Index (CTI) 1/8"	Volts	UL 746A	600+	185	—	600+/600+
Hot Wire Ignition, 1/16"	sec.	UL 746A	13	20	—	19/13.0
U.L. Temperature Index	°C @ 1/16"	UL 746B				
Elec. Properties			120	120	—	120/120
Mech. Properties						
w/w-o Impact			120/140	120/140	—	140/140

† This rating is not intended to reflect hazards presented by this or any other material under actual fire conditions
* In thin walls (0.025" to 0.045") it is suggested to use 6-10 mils in shrinkage
** In thin walls (0.025" to 0.050") it is suggested to use 1-4 mils in shrinkage
*** In thin walls it is suggested to use 4-6 mils in shrinkage
‡ Dry As Molded

APPENDIX K

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX K

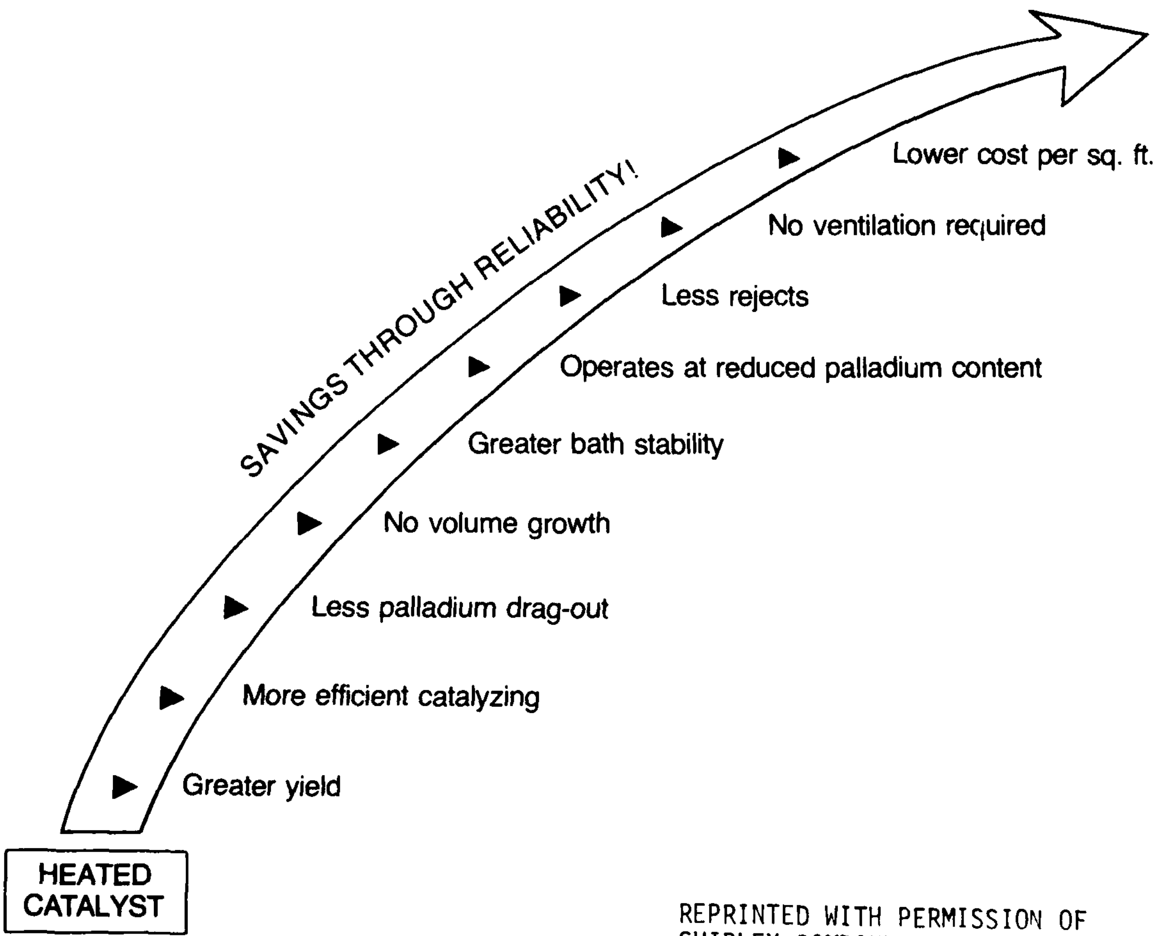
SHIPLEY PLATING SOLUTION SPECIFICATIONS

SHIPLEY

CATAPOSIT® 44

A Unique Catalyst for Plating on Plastic

CATAPOSIT 44 TAKES ADVANTAGE OF MAJOR NEW TECHNOLOGY THAT ALLOWS HEATED BATHS TO GENERATE IMPORTANT SAVINGS FOR YOU!

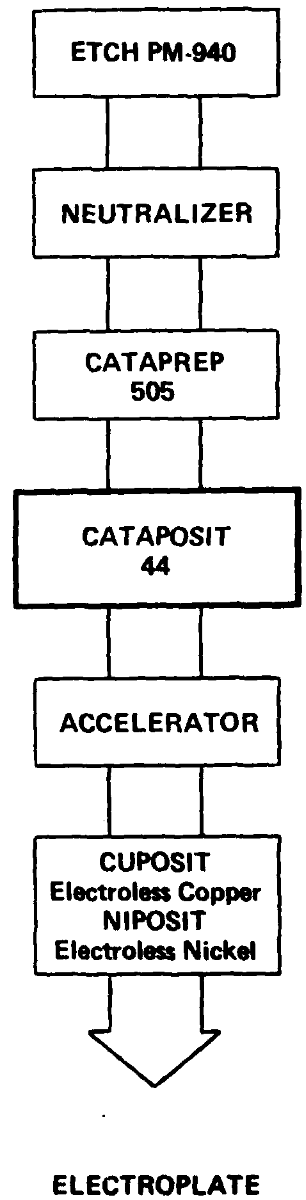


AND CATAPOSIT 44 CATALYST SYSTEM WILL PRODUCE BETTER PLATED PLASTIC PARTS!

These major benefits are due to the fact that 125,000 times more colloids are working for you.

CATAPOSIT 44

A Reliable Process for Plating ABS



DESCRIPTION

CATAPOSIT 44 Catalyst for plating-on-plastics was especially developed to reduce costs and produce better work more profitably. Its unique characteristics differ from all other tin-palladium catalysts that are on the market today. CATAPOSIT 44 Catalyst is characterized by extremely small colloids that penetrate into the smallest micropores of the etched plastic substrate. No other catalyst can equal this performance. These minute colloids are strongly adsorbed onto non-conductive surfaces resulting in uniform coverage.

FEATURES

- Better Adsorption to Etched Plastic. The size of CATAPOSIT 44 colloids creates many more anchor points and also provides stronger anchors.
- No Volume Growth. When operated as specified.
- Selective Plating. Broad tolerances for non-plating on plastisol racks or stop-off paint, even with electroless copper.

BENEFITS

- Greater Yield. Resulting from elevated temperatures.
- Bath Stability. At 120°F the unique qualities of CATAPOSIT 44 Catalyst enables you to derive the many benefits of a heated bath.
- Minimum Palladium Waste. Less drag-out. No silvery film formation. No volume growth.
- Non-corrosive, Non-fuming, Non-volatile.
- Steady State Operation. CATAPOSIT 44 Catalyst System can be operated for months, even years.

YIELD

When CATAPOSIT 44 bath is operated at 2% strength at 120°F, replenishment yield per gallon of CATAPOSIT 44 concentrate will be in excess of 10,000 sq. ft. of work surface.

CATAPREP 505

CATAPREP 505 is used in conjunction with CATAPOSIT 44 Catalyst to maintain normality of the bath. In addition, CATAPREP 505 acts as a chrome reducing agent, and displaces water and any other contaminants prior to entering the CATAPOSIT 44 bath.

CATAPOSIT 449

CATAPOSIT 449 is used with CATAPOSIT 44 during make-up and to economically replenish tin losses resulting from idle baths and/or to correct any improper replenishments which would cause the tin (or stannous) content to drop below minimum recommended values.

SHIPLEY COMPANY

INSTRUCTIONS FOR USE

CATAPOSIT 44 MAKE-UP

Add in order listed:	To make 100 Gallons	% by Volume
Step 1 — Distilled Water	83 gals.	83%
Step 2 — CATAPREP 505	10 gals.	10%
Step 3 — Mix thoroughly	-	-
Step 4 — Sodium Chloride*	175 lbs.	1.75 lbs./gal.
Step 5 — Mix until dissolved	-	-
Step 6 — CATAPOSIT 44	2 gals.	2%
Step 7 — Mix thoroughly	-	-
Step 8 — CATAPOSIT 449	0.5 gals.	.5%

CATAPREP 505 MAKE-UP

Step 1 — Distilled Water	85 gals.	85%
Step 2 — CATAPREP 505	10 gals.	10%
Step 3 — Mix thoroughly	-	-
Step 4 — Sodium Chloride*	150 lbs.	1.5 lbs./gal.
Step 5 — Mix until dissolved	-	-

BATH OPERATION

	CATAPOSIT 44	CATAPREP 505
Temperature:	100° to 120°F ± 5°F.	100° to 130°F is best.
Time:	2 to 4 minutes.	1 to 3 minutes.
Work Loading:	As preferred.	As preferred.
Agitation:	Agitate the work; do not aerate.	Aerate the bath vigorously with clean air.

If your catalyst bath is going to be idle for more than a week, cover it with a floating cover such as polyethylene film thereby protecting it from air.

BATH CONTROL & REPLENISHMENT

Maintain CATAPOSIT 44 bath between 70% and 100% bath strength by replenishing according to schedule below. Bath strength is easily determined by using Shipley Comparator or Color Standards. *The CATAPREP 505 bath can be readily* controlled by specific gravity readings and replenished from the schedule below:

CATAPOSIT 44		CATAPREP 505			
Bath Strength	Replenishment for 2% Cataposit 44 per 10 Gals. of Bath	Bath Strength	Specific Gravity at 60°F	Cataposit 505 Conc. addition per 10 Gals. of Bath	Sodium Chloride* per 10 Gals. of Bath
100%	none	100%	1.133	none	none
90%	Add 60 ml #44	90%	1.120	400 ml	1.5 lbs.
80%	" 120 ml "	80%	1.108	800 ml	3.0 lbs.
70%	" 180 ml "	70%	1.094	1200 ml	4.5 lbs.

CATAPOSIT 449 is used at make-up and when stannous chloride level in CATAPOSIT 44 bath approaches 2 grams per liter. 1% to 3% CATAPOSIT 44 baths should be operated between 2 to 6 grams per liter stannous chloride. For each gallon of CATAPOSIT 44 bath the addition of 11 ml of CATAPOSIT 449 will raise the stannous content by one (1) gram per liter.

ANALYTICAL PROCEDURE for CATAPOSIT 449

Step 1 — Analyze CATAPOSIT 44 bath for palladium content using Shipley Comparator or by Color Standards.
Step 2 — Add appropriate amount of CATAPOSIT 44 concentrate to bring palladium content to 100%.
Step 3 — Analyze (the 100% palladium content CATAPOSIT 44 bath) for stannous chloride content —see AN 44 analytical sheet.
Step 4 — Add CATAPOSIT 449 to raise stannous chloride to 6 grams per liter.

* Important: The grade of sodium chloride used is very important. For your convenience Shipley Company supplies a grade of sodium chloride that will provide you with the quality needed.

CATAPOSIT 44

FILTRATION

For best results, filtration of CATAPOSIT 44 bath is desirable. Use filters of polypropylene or dynel (5-10 micron filter porosity). In-tank filters having filter tube cores and slow pumping rates (3-5 turnovers per shift) are best to prevent introduction of air into the system. The flow should be adequate to keep the bottom of the tank clear. A bottom outlet for the filter is preferred. Wash filter cartridges with dilute HCl and DI water prior to use.

PLATING-ON-PLASTIC PROCESSING

CATAPOSIT 44 Catalyst System can be used instead of CATALYST 9F in Shipley plating-on-plastic processes, and is preferred for use in any plating-on-plastic line using tin-palladium catalyst. Use CATAPREP 505 solution as the immediately preceding step (instead of HCl). Rinse well after the CATAPOSIT 44 step, and then immerse the work in a Shipley ACCELERATOR for the length of time specified in the applicable Shipley instruction sheet. Consult your Shipley Technical Sales Representative to determine the process that will be best for your operation.

PROCESS PERFORMANCE

In order to achieve maximum performance CATAPOSIT 44 and CATAPREP 505 should be run in conjunction with one another. If circumstances prohibit the use of CATAPREP 505, please consult your Shipley Technical Sales Representative.

PRODUCT DATA

	CATAPOSIT 44	CATAPOSIT 449	CATAPREP 505
Palladium (approx.)	4.7 grams per liter	.15 grams per liter	-
Stannous Chloride (approx.)	210 grams per liter	350 grams per liter	-
Specific Gravity at 70°F	1.2	1.3	1.2
Acidity	acidic	acidic	acidic
Flammability	non-flammable	non-flammable	non-flammable
Color	dark brown	dark brown	pale yellow

SAFE HANDLING

WARNING! CATAPOSIT 44, 449 and CATAPOSIT 505 are corrosive acid solutions. They are harmful if swallowed. Avoid contact with skin, eyes and clothing. Avoid breathing of vapors. Wear chemical goggles, rubber gloves, and acid resistant clothing. Exercise due care in handling.

CAUTION: When using immersion heaters, failure to maintain proper volume level can expose tank and solution to excessive heat resulting in a possible combustion hazard, particularly when plastic tanks are used. Do not use stainless steel heat exchangers or immersion heaters of titanium or zirconium.

EQUIPMENT

Use tanks constructed of polyethylene, polypropylene, PVC, Lucite or glass, and racks of suitable 304-316 stainless steel, or racks coated with polyethylene, polypropylene, PVC, Teflon or equivalent. Important: Do NOT use racks of iron, steel, aluminum, magnesium, lead, zinc, cadmium. For heating use quartz electric immersion heaters, if steam or hot water coils are used, tantalum, Teflon or equivalent, or glass are recommended in that order.

STORAGE

Store in dry area at 50° to 90°F. Do not store in direct sunlight. Seal container when not in use. In case of spillage flush with large amounts of water.

SHIPLEY COMPANY

NEWTON, MASS. 02162 • 617-969-5500 *Regional Offices:* IRVINE, CALIF. • ELK GROVE, ILL. • WESTWOOD, MASS.

The Positive Approach

The Shipley P-T-H Process

- Cuposit Cleaner-Conditioner 1175A
- Preposit® Etch 746
- Cataprep® 404
- Cataposit® 44
- Cuposit Electroless Copper

A Proven Shipley Process

CUPOSIT® ACCELERATOR 19

Accelerator Used in the Shipley P-T-H Process

Accelerator 19 is a key step in the Shipley P-T-H (through hole plating) Process. Its important function is to modify adsorbed catalyst to allow quick and uniform metal deposition. Accelerator 19 promotes strong copper-to-copper bonds, while prolonging the electroless copper bath life by minimizing drag-in of catalyst. Accelerator 19 follows Cataposit 44 or Catalyst 9F in the Shipley P-T-H process.

ADVANTAGES

- Assures rapid and uniform electroless copper coverage.
- Provides for strong copper-to-copper bonds.
- Prevents voids that can be caused by over-aggressive acceleration.
- The bath is highly reliable, particularly when operated in the steady state mode.

Shipley . . . *specialists in electroless plating processes*

Bath Make-Up

Add 1 part of Accelerator 19 concentrate to 5 parts of deionized water, stir until bath is uniformly mixed.

Bath Operation

Operate the bath between 70 and 80°F. Rack boards vertically and immerse for 4 to 8 minutes. Part agitation is recommended using 3 to 5 strokes per minute. Bath loading should not exceed 2 square feet of surface area per gallon of bath. The work must be rinsed in cold water after Accelerator 19 and prior to electroless copper plating.

The Accelerator 19 bath can be operated in either a **Steady State** or **batch** mode. Steady state operation offers maximum reliability while batch operation is simpler and also reliable providing the bath is discarded according to our recommendations.

Bath Control

STEADY STATE OPERATION

Replenishment can be based on square feet of work processed or bath normality analysis.

A. Work Processed: For each 100 square feet of surface area processed per gallon of bath, remove 20% of bath volume and replace with fresh make-up as per schedule below.

B. Normality Analysis:

1. Determine normality using control procedure AN-19-N
2. Determine replenishment addition per schedule below.
3. Prior to adding Accelerator 19 concentrate, remove a volume of bath per schedule below.
4. Add Accelerator 19 concentrate and restore bath to working volume with deionized water.

REMOVAL AND REPLENISHMENT SCHEDULE PER 100 GALLONS

Bath %	Normality	Bath Removal	Accelerator 19 Addition
100	0.26	0 gallons	0 gallons
90	0.23	12 gallons	3 gallons
80	0.20	24 gallons	6 gallons
70	0.17	36 gallons	9 gallons

BATCH OPERATION

The point at which the bath should be discarded can be determined by square feet of work processed or analysis for dissolved copper.

A. Work Processed: Discard bath when 300 square feet of surface area has been processed per gallon of bath.

B. Copper Analysis: Periodically analyze the bath for dissolved copper using control procedure AN-19-Cu, discard bath when copper content exceeds 0.7 grams per liter.

Product Data

Accelerator 19 is a clear water-based acidic solution.

CHEMICAL AND PHYSICAL PROPERTIES

Specific gravity at 20/20°C. (approx.)	1.0
Color	water white
Flammability	non-flammable
pH (approx.)	<1

Handling Precautions

WARNING! Corrosive acid solution. Harmful if swallowed. Causes burns. Avoid contact with skin and eyes. Avoid breathing of vapors. Handle with care. Wear chemical goggles, rubber gloves, and protective clothing.

Equipment

The recommended material for tanks, racks and accessory equipment is non-pigmented polypropylene or polyethylene. Racks of 304 stainless steel, 316 stainless steel and teflon-coated may also be used. For alternative equipment recommendations, contact your local Shipley Technical Sales Representative.

Storage

Store only in original containers in a dry area at 50 - 90°F. Do not store in direct sunlight. Seal container when not in use.

DETERMINATION OF TOTAL ACID NORMALITY OF CUPOSIT ACCELERATOR 19 BATH. CONTROL PROCEDURE (AN-19-N).

I. PRINCIPLE

A sample of the bath is titrated with sodium hydroxide using bromophenol blue indicator.

II. REAGENTS

1. Sodium Hydroxide, 0.10N, standardized.
2. Bromophenol Blue indicator, 0.1%; Dissolve 0.5 gms. of indicator in 500 mls. of water.

III. PROCEDURE

1. Pipette 5.0 mls. of ACCELERATOR 19 bath into a 250 ml. Erlenmeyer flask and dilute to 100 mls.
2. Add bromophenol blue indicator and titrate with sodium hydroxide (0.1N) to the yellow-green to blue-purple endpoint.

IV. CALCULATION

$$\text{Total acid normality} = \frac{\text{ml. NaOH Normality}}{5}$$

DETERMINATION OF COPPER IN CUPOSIT ACCELERATOR 19 BATH. CONTROL PROCEDURE (AN-19-Cu).

I. PRINCIPLE

The copper is determined complexometrically with EDTA solution using an ammonia buffered solution at pH 10 with PAR indicator.

II. REAGENTS

1. EDTA 0.05M; Dissolve 18.61 gms. of EDTA disodium salt in water and dilute to 1 liter. Standardize with copper solution.
2. Ammonia buffer, pH 10; Dissolve 70 gms. of ammonium chloride in water, add 570 mls. of ammonia (S.G. 0.88) and dilute to 1 liter.
3. PAR indicator, 0.1%; Dissolve 0.1 gm. of 4- (2-Pyridylazo)- resorcinol in water and dilute to 100 mls.

III. PROCEDURE

1. Pipette 20 mls. of the bath into a 250 ml. Erlenmeyer flask and dilute to 50 mls.
2. Add 25 mls. of ammonia buffer (pH 10) and 10 drops of PAR indicator.
3. Titrate with EDTA (0.05M) from a 10 ml burette, until the pink color rapidly fades to yellow-green.

IV. CALCULATION

1 ml. 0.05M EDTA = 3.177 mg. Copper

$$\text{g/l Copper} = \frac{\text{mls. EDTA x Molarity x 63.54}}{\text{Aliquot (20 mls.)}}$$

FOR INDUSTRIAL USE ONLY

SHIPLEY COMPANY INC

2300 Washington Street
Newton, Mass 02162 — (617) 969-5500.
Regional Offices: Irvine, Calif. (714) 556-0240.
Elk Grove Village, Ill. (312) 956-6550.

SHIPLEY COMPANY

CUPOSIT® ELECTROLESS COPPER CP-70

USE

ELECTROLESS COPPER CP-70 is the first commercially available Electroless Copper for plating heavy thicknesses of high purity, ductile copper onto conductive or non-conductive substrates-- eliminating the need for electrolytic copper plating in many applications.

ADVANTAGES

Unlike all previous electroless copper baths, ELECTROLESS COPPER CP-70 will provide:

(1) At least two bends without fracture when plated over smooth surfaces.
(2) Plating rates of at least 1 mil thickness in four hours.
(3) A cyanide-free solution.
(4) Bright deposits.
(5) Excellent solderability.
(6) Uniform thicknesses.

ELECTROLESS COPPER CP-70 offers many potential applications in: Additive Printed Circuits; Hole Only Plating; Electroforming; Wave guides; Thick Film and Thin Film Circuits, and eliminating the strike in PTH applications.

PROCESSING INSTRUCTIONS

MAKE-UP

	For a 10-gallon Bath
16 parts Distilled Water	8 Gallons
1 part ELECTROLESS COPPER CP-70A	1/2 Gallon
2 parts ELECTROLESS COPPER CP-70M	1 Gallon

Then heat to 120° - 130°F and add:

1 part CUPOSIT Z	1/2 Gallon

Bath is now ready for operation.

OPERATION

Operate at 120° ± 2°F (preferable), otherwise 115°F minimum to 130°F maximum. Keep temperature constant. Agitate work continuously at 5 to 10 strokes per minute. Agitate solution by mechanical means or by re-circulating through a coarse filter. For a batch type operation, plan amount of work and desired thickness (see chart on reverse side). Discard bath after completion.

For a replenishable operation, cool bath after each day's use. (See replenishment instructions.)

CUPOSIT® ELECTROLESS COPPER CP-70

BATH LOADING

As a batch-type operation, the bath loading is restricted by the amount of ductile copper to be plated, as follows:

DESIRED COPPER THICKNESS	SURFACE AREA*/ GALLON OF BATH	PLATING TIME AT 120°F
0.25 mil	72 sq. in. (1/2 sq.ft.)	1 1/4 hours
0.5 "	36 " " (1/4 " ")	2 1/2 "
0.75 "	24 " " (1/6 " ")	3 3/4 "
1.0 "	18 " " (1/8 " ")	5 "

*Surface area to be plated.

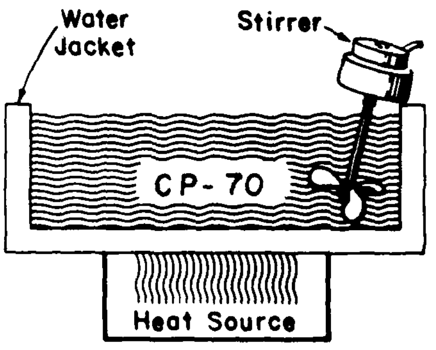
If heavier thicknesses are desired, transfer work to a fresh bath every two hours and use less bath loading in order to lessen plating time.

FILTRATION

For smooth deposits it is best to filter continuously through a coarse media, such as glass wool. DO NOT USE A FINE FILTER. Batch filtering every two hours is suitable, or a transfer to a fresh bath.

EQUIPMENT

Polyethylene or glass containers are satisfactory. CP-70 is operated HOT. Heat transfer is ideal for volume manufacture. Do not use immersion heaters as direct localized heat is not suitable. See sketch for water jacket set-up recommended. Use a polyethylene, Teflon or glass stirrer (if continuous work agitation is not provided).



SAFE HANDLING

Safety glasses, gloves, and clothing should be worn. Use precautions as in handling formaldehyde and caustic solutions. Wash exposed areas with copious amounts of water.

STORAGE

Store in a dry area at 50°-90°F. Keep sealed when not in use. Shelf-life is at least 12 months if stored unopened under these conditions.

SHIPLEY COMPANY INC.

2300 Washington St., Newton, Mass. 02162 • (617) 969-5500   727 East 223rd St., Torrance, Calif. 90502 • (213) 775-7181

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX L

APPENDIX L

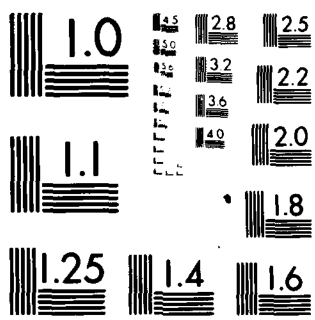
DESIGN INSTRUCTION - PHALANX CLOSE-IN-WEAPON-SYSTEM

DI 444-A-002A

AD-A093 446 GENERAL DYNAMICS CORP POMONA CA POMONA DIV F/G 13/8
MANUFACTURING TECHNOLOGY PROGRAM FOR MICROWAVE COMPONENTS.(U)
APR 80 W L MACTURK N66001-79-C-0022
UNCLASSIFIED NAVSEA-MT-S-617-78 NL

4 OF 4
ADA
093446

END
DATE
FILMED
2-81
DTIC



MICROCOPY RESOLUTION TEST CHART

GENERAL DYNAMICS
Pomona Division

DESIGN INSTRUCTION

MODEL Pilotline NO. SUPERSEDED NO. 433-BE-086D

DATE 5 January 1977 PAGE 1 OF 30

SPECIFICATION REFERENCE WS 13902D

SUPPORTING DATA REFERENCE

SUBJECT: CIWS PILOTLINE ENVIRONMENTS

PURPOSE: To establish the environmental requirements for CIWS pilotline equipment assemblies and packages and to standardize the test methods for environmental qualification.

INSTRUCTION: All pilotline specifications for equipment assemblies and packages are to be compatible with these environments. (The environments for purchased piece parts are contained in DI-433-BE-332).

The CIWS Pilotline environments are defined in Paragraphs 1.0 through 6.0. The test methods for environmental qualification are contained in Appendix A. These tests are in terms of military or industry test methods. This allows the use of standard test methods and set-ups and reduces testing costs.

Gun induced environments are provided for both 25 mm and 30 mm (GAU-8A) growth guns. The 30 mm environments apply only to the outer structure (barbette, electronics enclosure, train platform, and elevation mount structure). The yoke, elevation gear train, servo motors and all of the electronics are designed for the 25 mm environments.

The allocation of the environments to the various CIWS elements is provided in Figure 1.

Load distributions in terms of shear and bending moments due to combined load environments (survival) and near miss shock are contained in DI-444-A-003.

Table A-IV provides a summary of the thermal environments for CIWS packages.

"A" *B.H.T.* "A" *R.A.S.* "A" *C.R.H.* *4-27-77*

XIV-2

PREPARED BY *B.H. T...* SECTION *26* APPROVED BY *T...* SYSTEMS ENGINEERING APPROVED BY *C.R.H...* PROJECT OFFICE

1.0 GENERAL

The CIWS system will be deployed on board many different ship classes. The geographical deployment of the CIWS and its supporting logistics will be worldwide and climatic conditions will range from equatorial heat and humidity conditions to artic cold. The CIWS must be capable of effective and continuous operation under realistic combinations of its own ship environments, the climatic environments as specified in MIL-STD-210, the environments that the enemy forces can be expected to induce and self-generated environments.

The system shall operate with normal performance when performing under environmental conditions noted under "Normal Service." In those cases where "Reduced Operating Capability" is noted, the system shall function but it is not required that the performance be within the tolerances specified for "Normal Service." Reduced capability may include reduced elevation coverage, kill probability and altered minimum engagement range. In the cases specifying "Withstand," the system is to withstand exposure to the conditions without damage and recover to normal performance when less severe conditions exist.

The environmental requirements are organized in accordance with the primary source of the environment as follows:

a) climatic
b) shipboard
c) CIWS generated
d) threat induced
e) combination loading
f) bench handling
g) transportation

2.0 CLIMATIC ENVIRONMENTS

2.1 Thermal Air Low Temperature

a) Equipments exposed to the elements shall operate with external air temperature at -28°C (-19°F) continuous. (MIL-STD-210B, 5.2.2.2.2).

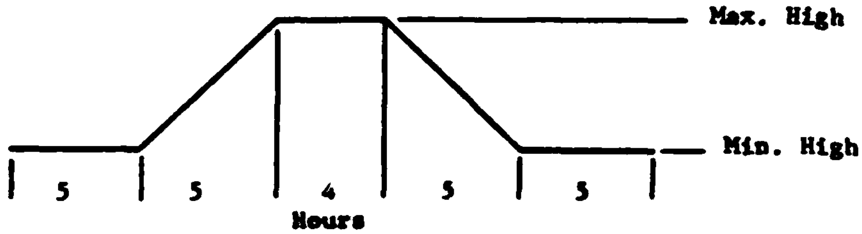
b) The CIWS equipments shall be able to survive (not operate in) a continuous -40°C (-40°F) without permanent damage. (MIL-STD-210B, 5.2.2.2.3) A

2.2 Thermal Air High Temperature

a) Equipments exposed to the elements shall operate with external air high temperatures between 32°C (90°F) and 46°C (114°F) according to the below daily duty cycle (MIL-STD-210B, 5.2.2.1.2).

b) Equipments shall be able to survive a continuous air temperature high between 32°C (+90°F) and 71°C (160°F) according to the below daily duty cycle.

c) Daily duty cycle



2.3 Solar Radiation

Equipments exposed to the elements shall operate when exposed to solar radiation. The solar power w[illegible] vary from 0 to 90 watts/ft^2 in accordance with the duty cycle of [illegible].2. This requirement shall be used in conjunction with 2.2 when computing surface temperatures. Composition of solar energy is: 51 percent infrared, 44.5 percent visible, and 4.5 percent ultraviolet.

2.4 Humidity

The equipments exposed to the elements shall maintain normal service when operating either intermittently or continuously at ambient relative humidity from 5% to 95%. Packaged parts in storage shall withstand any continuous relative humidity from 95% to 2%.

2.5 Sea Temperature

The CIWS shall maintain normal service when sea water at a temperature of 38°C (100°F) or less is used as the basic cooling source for any cooling system.

2.6 Wind Loading

The CIWS shall maintain its normal performance in turbulent smooth winds with velocities up to 75 knots (17 pounds per square foot on projected areas exposed to the wind). The CIWS shall withstand without damage, winds having relative velocities of 100 knots (30 pounds per square foot).

2.7 Blowing Particles

The external portions of the equipment including RV front panels shall operate when exposed to blowing particles in accordance with the below schedule:

Snow:	.02 to .2 mm (7.9×10^{-4} to 7.9×10^{3}) diameter
(MIL-STD-210B, Para. 5.1.12.1, 5.1.12.3)	6.9 gm/m^2/sec (1.4 lb/ft^2/sec)
	26 knot wind
	-15°C (5°F)
Sand and Dust: (MIL-STD-210B, Para. 5.1.21.3)	.074 to .35 mm (2.91×10^{-3} to 13.8×10^{-3} in) diameter
	1.06 gm/m^3 (6.61×10^{-5} lb/ft^3)
	35 knot wind
	21°C (70°F)

A

2.8 Atmospheric Pressure

A

The CIWS shall operate in atmospheric pressures varying between 12.8 to 15.4 psia (26.06 to 31.35 in Hg). Packaged parts in Navy logistics system must survive atmospheric pressures as low as 1.68 psia (3.42 in Hg, 50,000 ft altitude) during air transportation.

2.9 Rain

The CIWS shall maintain normal service in rain of up to 4 mm per hour. The equipment shall withstand rainfall rates up to 7 inches per hour with an average of 1 inch per hour for a 12 hour period.

2.10 Fungus

The CIWS shall use fungi resistant materials in accordance with MIL-STD-454, Requirement 4 where possible. Equipment with non-resistant materials shall not show deterioration after being subjected to MIL-STD-810, test method 508.1. A

2.11 Ice Loading

The CIWS shall be capable of operation under icing conditions. Ice may accumulate at rates up to 1 in/hr on surfaces that do not utilize ice build-up prevention techniques. Means shall be provided for prevention of icing and/or for de-icing of adjoining surfaces which are required to move relative to each other and

on surfaces on which accumulations of ice will prevent satisfactory operation. The CIWS shall operate normally with all surfaces except the search and track radar windows, gun, magazine and yoke covered with 4.5 lb per square foot of ice on all horizontal surfaces and 2.25 lb per square foot on all vertical surfaces. The CIWS shall survive an ice loading of 6.0 lb per square foot of ice on all horizontal surfaces and 3.0 lb per square foot on all vertical surfaces. (MIL-STD-2103, Para. 5.2.2.13.3) During system operation under icing conditions, minimum air temperature will be -18°C (0°F) and maximum wind speed will be 50 knots. A

2.12 Salt Fog

The enclosures of equipment shall resist deterioration when subjected to a 5 percent sodium chloride solution for a period of 200 hours. Interior equipment[x] shall show no deterioration and shall maintain normal service when subjected to a 5 percent sodium chloride solution for 48 hours. Interior equipment having 2 enclosures between it and the outside atmosphere shall not be sujected to a salt fog test. A

3.0 SHIPBOARD ENVIRONMENTS

3.1 Shipboard Magnetic Conditions

The CIWS shall operate normally when subject to slowly fluctuating direct current induced degaussing magnetic fields up to 20 gauss max. The CIWS shall be capable of returning to operation as specified within 60 minutes after the deperming operation.

3.2 Gun Blast

The CIWS shall maintain normal service when subject to gun blast of 7.5 psi with a positive impulse of 10 psi-milliseconds repeated at 40 times per minute for 10 minutes.

3.3 Ship Motion

3.3.1 Ship Motion Conditions. The CIWS shall be designed for installation in various classes of ships. Ship motion characteristics vary with ship class. For design purposes the motions described in Table I shall be used, combined as follows:

a) Normal Service (Full Operating Capability)

Maximum roll, pitch and yaw positions, velocities, or accelerations may occur simultaneously.

b) Reduced Service (Reduced Operating Capability)

Maximum roll, pitch, and yaw positions, velocities or accelerations may occur simultaneously.

x Enclosures

c) **Extreme Service (Non-Operating, Withstand and Recover)**

Maximum positions, velocities, and accelerations shall not be assumed to occur simultanebusly. The maximum position, velocity, or acceleration about any one of the axes (for extreme service condition) shall be assumed to combine simultaneously with maximum positions, velocities and accelerations of the normal service condition about the other two axes. Recovery to normal operation shall be automatic and within 1 second after an extreme service condition is removed.

3.3.2 Ship Inclination, Operate. The group shall operate with ship continuous inclinations of ±15 degrees list (roll) and ±5 degrees trim (pitch). When ship inclinations are combined with ship motions, ship amplitude extremes of Table 1 are the limits specified for operation.

3.3.3 Ship Inclination, Survive. The CIWS equipment shall withstand a 60 degree roll when it is in a non-operating or stowed condition.

3.3.4 Ship Turning Rate. The group shall operate normally for ship turning rates of 5 deg/sec for a maximum of [illegible] seconds. The system shall be capable of reduced performance for turning rates of 18 deg/sec for a maximum of 10 seconds.

3.4 Ship Vibration

The equipment with the exception of the cannon (M61A1) and its magazine shall withstand Type 1 vibration requirements as specified in MIL-STD-167B. The vibration levels of Table II are expected during vibration qualification per MIL-STD-167B. Equipment is to operate with acceptable performance during two hours of vibration at the maximum levels indicated along each axis. The Table II vibration levels represent test levels and not normal shipboard operational levels. During maneuvers in rough seas the levels will be about half of the table values. During calm seas and steady heading of the ship, the levels will be about one-tenth of those shown.

3.5 Wave Loading

The CIWS top side mount enclosures shall withstand a wave load equivalent to a static load of 1000 pounds per square foot on vertical projected areas except the radar servo structure which shall withstand an equivalent static load of 500 pounds per square foot.

3.6 Sea State

The CIWS shall maintain normal service in any sea state from zero to five (inclusive). Maintenance shall not be performed in a sea state greater than 5. The survival sea state is sea state 8.

3.7 Ship Internal Temperature

The LCP shall operate with air temperature between 0° and 50°C (32 and 122°F).

4.0 CIWS GENERATED ENVIRONMENTS

4.1 Acoustic Environments

The CIWS shall operate normally in its own acoustic environment and when in close proximity to other equipment generating noise. The free-field peak levels for nearby jet aircraft and missile launch can be as high as 160 dB and 164 dB, respectively. The CIWS shall not generate noise above 95 db except when firing. Equipment in enclosed areas shall not generate airborne noise in excess of that permitted for Grade C equipment in MIL-STD-740. A

4.2 Acoustic Environment for Growth Guns

The Pilotline configuration is to be designed to minimize future structural changes due to the more severe environments that result from up-gunning. As indicated in Figure 1, the following structural elements are to be designed for the 30 mm growth requirements:

a. Barbette
b. Electronic enclosure
c. Equipment platform
d. Train platform
e. Elevation mount

All other structure and all electronic components are to be designed for a 25 mm growth gun. A

4.2.1 25 mm Gun Acoustics. 25 mm gun environments are based based on early GAU-7 and caseless ammunition data including:

Rate of fire: 3000 SPM
Muzzle position relative to elevation tunnion: 83 inches
Projectile kinetic energy: 106,000 FT-LB
Charge weight: 2450 grains

* Sound pressure levels in decibels (dB) are referenced to 0.0002 Dynes/CM^2.

The interior acoustic levels for the 25 mm gun are shown in Figure 2. These are to be applied to equipment as indicated in Figure 1.

4.2.2 30 mm Gun Acoustics. The design for a growth gun is based on the GAU-8A environment. Significant parameters for the acoustic environment are:

Rate of fire: 3000 SPM
Muzzle position relative to elevation trunnion: 65 inches
Projectile kinetic energy: 148,200 FT-LB
Charge weight: 2400 grains

Maximum blast loads induced by the 30 mm growth gun on the external structure and the firing angles at which they occur are shown in Table III and Figure 3. The reflected blast loads on the electronics enclosure can be as great as 40 to 60 psi for -25 degrees elevation and train angles near 165 degrees. Due to the low probability of ship installations permitting this condition to occur, the electronics enclosure will be designed for the maximum reflected pressure of 11 psi that occurs at -25 degrees elevation and ±120 degrees train. Beyond ±120 degrees train, the elevation angle must be increased to 0 degrees in order not to exceed the 11 psi design load.

The CIWS external structure shall have a fatigue life in excess of 2 hours when exposed to the 30 mm acoustically induced environment of Figure 4.

4.3 25 mm Gun Vibration

The equipment shall operate normally when subjected to the appropriate 25 mm gun vibration environments as specified in Figure 5.

The vibration consists of narrow band random and sinusoidal components at all gun fire harmonics below 1000 Hz and a predominantly broadband random content above 1000 Hz.

Vibration varies with position in the CIWS structure and according to the mounting provisions for the various equipment items. Vibration envelopes given in Figure 5

are specified at the package side of the designated isolators. Vibration levels or components within the packages can be substantially higner. Gains of 3 to 10 apply for conventional lowly damped packaging while highly damped designs will have gains from 1.5 to 3. Use of internal vibration isolation may be warranted where components have unusual sensitivity to vibration.

4.4 Mount Motion Environment

Equipments housed in the CIWS radome assembly shall be designed to operate under the loading induced by base motion of the mount elevation and train axes. These axes have the below slew and acceleration capability.

	Slew	Maximum Acceleration	Slew into Buffers
a) Elevation	1.6 Rad/s	14 Rad/s^2	1.6 Rad/s
b) Train	2.2 Rad/s	14 Rad/s^2	2.2 Rad/s

Mechanical stop is accomplished at constant deceleration ($\pm$10%) in 5 degrees in train and 10 degrees in elevation. The CIWS components must survive this shock.

4.5 Gun Recoil

The growth gun recoil forces shall not exceed:

Recoil force during burst: +15,000 pounds
(Acting through elevation axis) -0 pounds

Counter recoil at end of burst: -8000 pounds

A

4.6 Controlled Internal Environments

The CIWS shall have the ability to control the temperature of the electronics housed internal to the system. The system

Environmental Control Group (ECG) provides minimum and maximum temperature control, condensation control and radar waveguide pressurization. The amount of temperature control depends on the location within the system. The ECG will control the air environment to the electronics within the electronics enclosure 100% of the time, except during periods of casualty and preventative maintenance. The electronics within the electronics enclosure shall be required to operate in the environments specified below and shall also survive the environment specified in paragraphs 2.1, 2.2, 2.3, and 2.4.

4.6.1 ECG Maximum Air Temperature Operate (Cooling Cycle). The maximum delivered air temperature from the ECG shall not exceed 46°C (114°F) dry bulb. The return air temperature to the ECG shall not exceed 62°C (144°F).

4.6.2 ECG Minimum Operating Air Temperature (Heating Cycle).

4.6.2.1 With the electronic equipment non-operating, the minimum delivered air temperature shall be maintained at -12 ±3°C (+10 ±5°F) in climatic conditions as low as -29°C (-20°F).

4.6.2.2 With the electronic equipment operating, the minimum delivered air temperature shall be maintained at 4° ±3°C (+40 ±5°F) in climatic conditions as low as -29°C (-20°F).

4.6.3 Waveguide Air Pressurization. Waveguide pressure shall be maintained by the ECG at 3.4 ±2.6 PSIG for a maximum input flow of 15.0 in^3/min. The dew point of the conditioned air shall not exceed 15% relative humidity.

4.6.4 Air Humidity Operate. The humidity of the electronic enclosure interior shall be controlled such that there is no condensation.

4.6.5 ECG Air Pressurization. The conditioned air pressure to the electronics shall not be less than 1.5 inches water gage and the air flow into the electronics enclosure shall not be less than 640 cu. ft. min.

4.7 Controlled Transmitter and Power Supply Units Environment

The CIWS uses a liquid-to-liquid heat exchanger with a heater to control the radar transmitter environment. The transmitter shall operate with a maximum coolant (ethylene glycol) return temperature of +66°C (150°F). The transmitter shall transfer 40,600 British Thermal Units per hour (BTU/hr) (11.3 KW) maximum to the coolant. The coolant shall be supplied at 10.0 gallons per minute (gpm) and 130 PSIG. The coolant input temperature will be 46°C (+115°F).

4.8 Barbette and Mount Non-Controlled Internal Air Temperature

The equipment shall operate in non-controlled air environment that can reach a maximum of 66°C (+150°F), (the peak is caused by solar radiation and self-generated heat) and a minimum of -29°C (-20°F).

4.9 Radar Servo Structure Assembly Temperature Control

The minimum temperature is controlled in the radar servo assembly through the use of a heater/blower combination. The minimum operating temperature shall be maintained at 4°C (+40°F). Maximum radome internal air temperature shall not exceed 66°C (+150°F). The radar servo assembly heater shall be turned off when the internal temperature exceeds 38°C (100°F).

5.0 THREAT INDUCED ENVIRONMENT

5.1 Shock Loading

The equipment shall withstand shock loading induced by subsurface HE warhead detonation of Grade A, deck-mounted, Class II equipment in accordance with MIL-S-901C. The CIWS uses resilient mounts and the shock accelerations seen by the system will vary as specified in Table IV.

The near miss shock accelerations of Table IV are based on the method of NAVSHIPS 250-423-31. The vertical and lateral shock accelerations result from maximum velocity changes of 96 and 38 inches per second, respectively. Shock loads have been mitigated by shock isolators located between the deck and the electronic enclosure, the deck and the barbette equipment platform and the top of the barbette and the mount platform. The search and track antennas, enclosure drawers and the electronics are vibration isolated. DI-433-BE-40B defines the isolator characteristics and their rattle space requirements.

DI-444-A-003 defines the shock loads throughout the system for structural design.

6.0 COMBINATION LOADING

6.1 Combined Load Operating Capability

The CIWS shall operate normally for the combined operational loads for wind, ice, gun blast, ships motion, and gun recoil of paragraphs 2.6, 2.11, 3.2, 3.3.1 and 4.4, respectively.

6.2 Combined Survival Loading

The CIWS shall withstand the combined survival loads for ice, ships motion, and waves of paragraphs 2.11, 3.3.1 and 3.5, respectively. A

7.0 BENCH HANDLING

On the package level the equipment will be subjected to bench handling shocks as defined in MIL-STD-810C, Method 516.2, Procedure V and will operate normally after the applied shocks. A

8.0 TRANSPORATION

Transporation of the CIWS and spares can take place in trucks, trains and aircraft for long durations. This transporation environment results in a maximum of 1.5 g peak vibration in all axes. Lifting equipment and lifting attach points shall be designed for 5 g loads.

Table 1

Ship Motion Characteristics for System Design
(Reference: Table 3 of WS 13902D)

A) Ship Motion: Max amplitude (DE 1040)

	Full Capability		Reduced Capability		Withstand and recover	
	Ampl. (Deg)	Period (Sec)	Ampl. (Deg)	Period (Sec)	Ampl. (Deg)	Period (Sec)
Sinusoidal:						
Roll	±25	8.5	±35	8.5	±45	8.5
Pitch	±5	7	±8	7	±15	7
Yaw	±2.5	7	±4	7	±7.5	7

B) Ship motion: Max acceleration (LST 1156)

	Full Capability		Reduced Capability		Withstand and recover	
	Ampl. (Deg)	Period (Sec)	Ampl. (Deg)	Period (Sec)	Ampl. (Deg)	Period (Sec)
Sinusoidal:						
Roll	±20	6	±30	6	±45	6
Pitch	±5	4	±8	4	±15	4
Yaw	±2.5	4	±4	4	±7.5	4

The above LST ship motions can produce the following linear accelerations at a point 182 feet forward and 32 above the LST center of gravity.

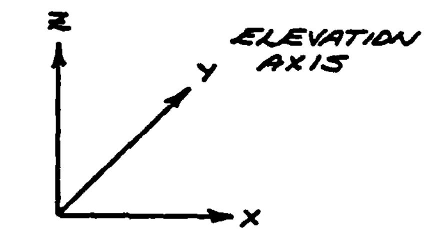
	Full Capability & Maintenance	Reduced Capability	Withstand and recover
Vertical*	1.3 g	2.2 g	3.6 g
Athwartship	1.0 g	1.5 g	2.2 g
Longitudinal	.4 g	.7 g	1.6 g

* Gravity bias not included.

Table II

System Maximum Responses for MIL-STD-167B Test

Component	Input Axis	Response Curve*	Component	Input Axis	Response Curve*
Barbette, Top	X	1	Gun Muzzle	X	5
	Y	1		Y	5
	Z	4		Z	5
Train Platform	X	2	Gun Ball J oint	X	2
	Y	2		Y	2
	Z	2		Z	2
Mount, Bottom	X	2	Magazine, Front	X	2
	Y	2		Y	2
	Z	2		Z	2
Mount, Top	X	2	Barbette Platform, Edge	X	1
	Y	2		Y	1
	Z	2		Z	6
Track Radome, Bottom	X	3	Barbette Platform, Center	X	1
	Y	3		Y	1
	Z	3		Z	6
Lower and Upper Track Isolator Support	X	3	Electronics Encl, Top	X	4
	Y	3		Y	4
	Z	3		Z	4
Microwave Receiver, Track Antenna	X	3	Double RU, (Signal Processor)	X	4
	Y	3		Y	4
	Z	3		Z	4
Search Antenna, Base	X	3	Single RU, (Signal Generator)	X	4
	Y	3		Y	4
	Z	3		Z	4



AXIS SYSTEM

*Response curves are defined on next page.

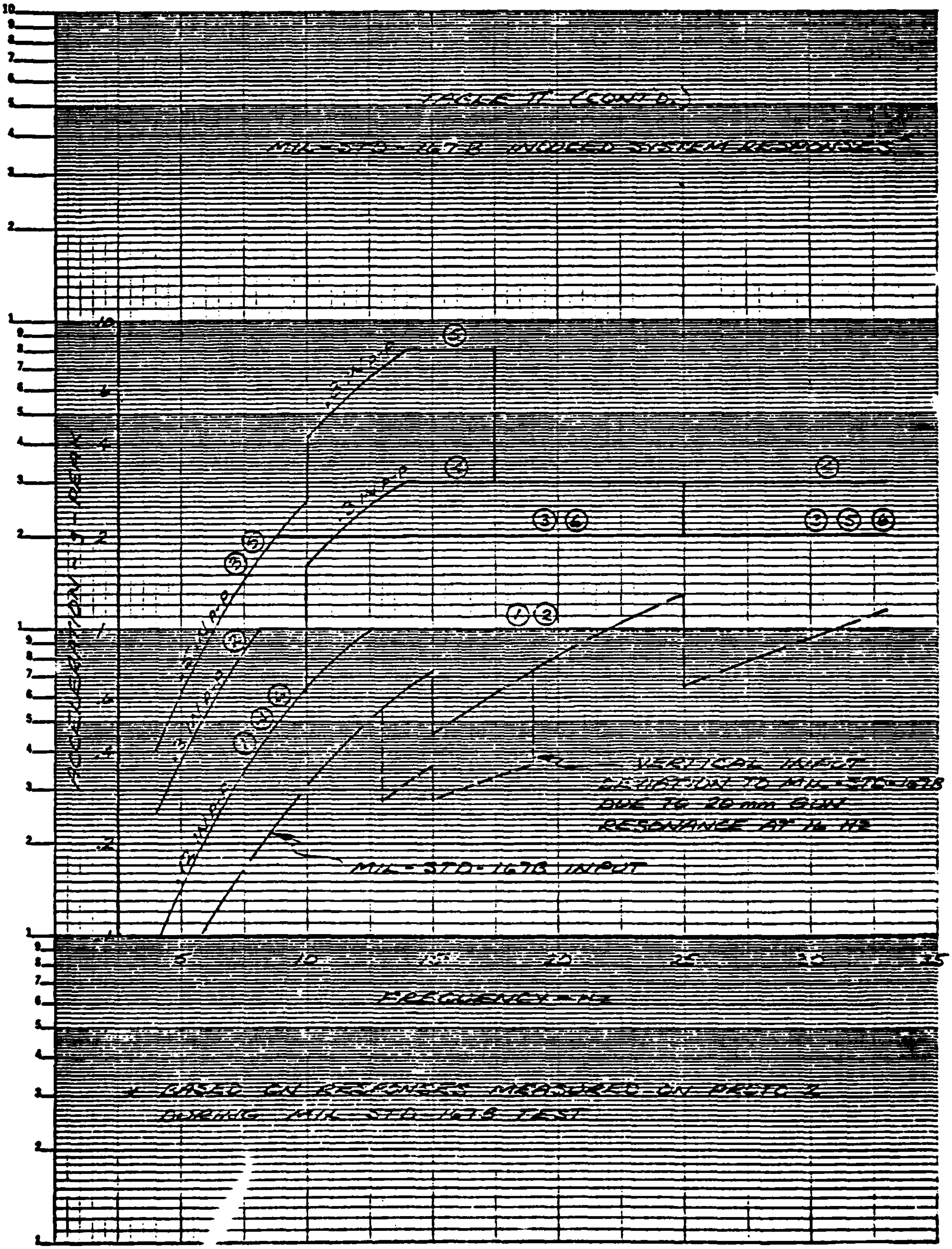


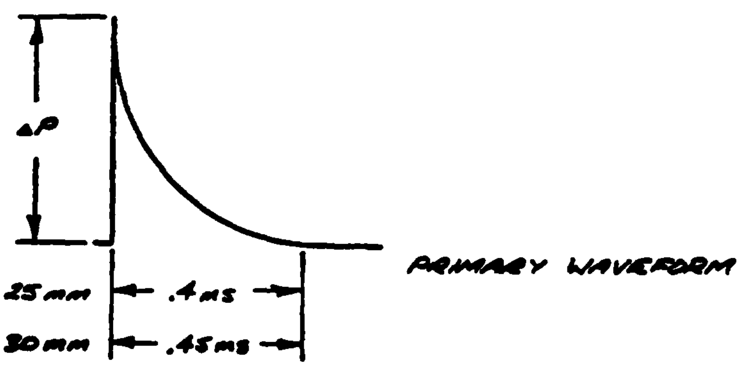
TABLE II (CONT'D)
MIL-STD-167B INDUCED SYSTEM RESPONSES
ACCELERATION - g - PEAK
VERTICAL INPUT
DEVIATION TO MIL-STD-167B
DUE TO 20 mm GUN
RESONANCE AT 16 HZ
MIL-STD-167B INPUT
FREQUENCY - HZ
* BASED ON RESPONSES MEASURED ON PROTO 2
DURING MIL-STD-167B TEST

Table III

30 mm Gun Blast Pressures for Structural Design

Structure	Firing Angle Elev. (Deg)	Firing Angle Train (Deg)	Reflected Blast Pressure 30 mm (PSI)
Barbette Panel	0	0, ± 90	3.0
	-25	0, ±90	8.0
	-25	±45, ±135	18.0
	0	±45, ±135	5.0
Electronics Encl.	0	±120	5.0
	0	±135	8.5
	0	±165	11.0
	-25	±120	11.0
Mount	0	*	2.5
	-25	*	8.0
Radar Servo Structure	*	*	1.9

*Does not vary with angle.



** Blast loads do not apply to the Local Control Panel or Remote Control Panel.

FIG

PILOTLINE CIWS ENVIRONME

				CLIMATIC																	
	ITEM	HARD MOUNTED	VIBRATION ISOLATED	2.1a THERMAL AIR LOW TEMP. - OPERATE	2.1b THERMAL AIR LOW TEMP. - SURVIVE	2.2a THERMAL AIR HIGH TEMP. - OPERATE	2.2b THERMAL AIR HIGH TEMP. - SURVIVE	2.3 SOLAR RADIATION	2.4 HUMIDITY	2.5 SEA TEMPERATURE	2.6 WIND LOADING	2.7a BLOWING PARTICLES OPERATE	2.7b BLOWING PARTICLES SURVIVE	2.8 ATMOSPHERIC PRESSURE	2.9 RAIN	2.10 FUNGUS	2.11 ICE LOADING	2.12 SALT FOG	3.1 SHIPBOARD MAGNETIC	3.2 GUN BLAST	3.3
1	LOCAL CONTROL PANEL		X		X		X		X			X	X			X		X	X		X
2	REMOTE CONTROL PANEL		X		X		X		X			X	X			X		X	X		X
3	REMOTE INDICATOR PANEL		X		X		X		X			X	X			X		X	X		X
4	RADAR SERVO ASSEMBLY																				
5	STRUCTURE, RADAR SERVO	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
6	GIMBAL ASSY., SEARCH		X		X		X		X							X		X	X		X
7	ANTENNA, SEARCH		X		X		X		X							X		X	X	X	X
8	ELECTRONICS, SEARCH		X		X		X		X							X		X	X		X
9	RADOME, SEARCH	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
10	GIMBAL ASSY. TRACK		X		X		X		X							X		X	X		X
11	ANTENNA, TRACK		X		X		X		X							X		X	X	X	X
12	ELECTRONICS, TRACK		X		X		X		X							X		X	X		X
13	RADOME, TRACK	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
14	MICROWAVE ASSY.		X		X		X		X							X		X	X		X
15	VERTICAL GYRO ASSY.		X		X		X		X					X		X		X	X		X
16	RATE GYRO ASSY.		X		X		X		X					X		X		X	X		X
17	ISOLATORS, VIBRATION	X			X		X		X							X		X	X		X
18	ENVIRONMENTAL CONTROL	X			X		X		X				X	X		X		X	X		X
19	ELEVATION MOUNT																				
20	STRUCTURE MOUNT	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
21	GEAR BOX ASSY., ELEV.	X			X		X		X		X					X	X	X	X	X	X
22	GEAR BOX ASSY., TRAIN	X			X		X		X		X					X	X	X	X	X	X
23	INSTRUMENTATION ASSY., TRAIN	X			X		X		X							X		X	X		X
24	DATA BOX, ELEV.	X			X		X		X							X		X	X		X
25	TORQUE MOTORS, SERVO	X			X		X		X		X			X		X	X	X	X		X
26	ROTARY JOINTS	X			X		X		X							X		X	X		X
27	GUN / YOKE ASSY.																				
28	STRUCTURE, YOKE	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
29	GUN	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
30	MAGAZINE	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X

2

FIGURE 1

RONMENTAL REQUIREMENT ALLOCATION MATRIX

	SHIPBOARD										CIWS														MISC.				
T FOG	3.1 SHIPBOARD MAGNETIC	3.2 GUN BLAST	3.3.1 SHIP MOTION	3.3.2 SHIP INCLINATION-OPERATE	3.3.3 SHIP INCLINATION-SURVIVE	3.3.4 SHIP TURNING RATE	3.4 SHIP VIBRATION	3.5 WAVE LOADING	3.6 SEA STATE	3.7 SHIP INTERNAL TEMPERATURE	4.1 ACOUSTIC NOISE	4.2.1 25 mm GUN ACOUSTICS	4.2.2 30mm GUN ACOUSTICS	4.3 25mm GUN VIBRATION	4.4 MOUNT MOTION	4.5 GUN RECOIL	4.6.1 MAX. TEMP.-OPERATE	4.6.2 MIN. TEMP.-OPERATE	4.6.3 WAVEGUIDE PRESSURIZATION	4.6.4 AIR HUMIDITY-OPERATE	4.6.5 AIR PRESSURIZATION	4.7 TRANSMITTER TEMP.	4.8 BARBETTE & MOUNT NON-CONTROLLED TEMP.	4.9 RADAR CONTROLLED TEMPERATURE	5.1 SHOCK LOADING	6.1 COMBINED LOAD-OPERATE	6.1 COMBINED LOAD-SURVIVE	7.0 BENCH HANDLING	8.0 TRANSPORTATION
	x		x	x	x		x		x	x	x														x				x
	x		x	x	x		x		x	x	x														x				x
	x		x	x	x		x		x	x	x														x				x
							x																						
	x	x	x	x	x			x	x		x	x		x	x										x	x	x		
	x		x	x	x				x		x	x		x	x									x	x				
	x	x	x	x	x				x		x	x		x	x									x	x				
	x		x	x	x				x		x	x		x	x									x	x			x	
	x	x	x	x	x			x	x		x	x		x	x										x				
	x		x	x	x				x		x	x		x	x									x	x				
	x	x	x	x	x				x		x	x		x	x									x	x				
	x		x	x	x				x		x	x		x	x									x	x			x	
	x	x	x	x	x			x	x		x	x		x	x										x				
	x		x	x	x				x		x	x		x	x				x					x	x			x	
	x		x	x	x	x			x		x		x		x									x	x			x	
	x		x	x	x	x			x		x	x		x	x									x	x			x	
	x		x	x	x				x		x	x		x	x									x	x				
	x		x	x	x				x		x	x		x	x									x	x				
							x																						
	x	x	x	x	x			x	x		x		x		x	x									x	x	x		
	x	x	x	x	x			x	x		x	x		x	x	x							x		x	x	x		
	x	x	x	x	x			x	x		x	x		x	x	x							x		x	x	x		
	x		x	x	x				x		x	x		x	x								x		x			x	
	x		x	x	x				x		x	x		x	x								x		x			x	
	x		x	x	x				x		x	x		x	x	x							x		x			x	
	x		x	x	x				x		x	x		x	x				x				x		x				
							x																						
	x	x	x	x	x			x	x		x	x		x	x	x									x	x	x		
	x	x	x	x	x			x	x		x	x		x	x	x									x	x	x		
	x	x	x	x	x			x	x		x	x		x	x	x									x	x	x		

FIGUR

PILOTLINE CIWS ENVIRONMENTA

				CLIMATIC																		
	ITEM	HARDMOUNTED	VIBRATION ISOLATED	2.1a THERMAL AIR LOW TEMP.—OPERATE	2.1b THERMAL AIR LOW TEMP.—SURVIVE	2.2a THERMAL AIR HIGH TEMP.—OPERATE	2.2b THERMAL AIR HIGH TEMP.—SURVIVE	2.3 SOLAR RADIATION	2.4 HUMIDITY	2.5 SEA TEMPERATURE	2.6 WIND LOADING	2.7a BLOWING PARTICLES OPERATE	2.7b BLOWING PARTICLES SURVIVE	2.8 ATMOSPHERIC PRESSURE	2.9 RAIN	2.10 FUNGUS	2.11 ICE LOADING	2.12 SALT FOG	3.1 SHIPBOARD MAGNETIC	3.2 GUN BLAST	3.3.1 SHIP MOTION	3.3.2 SHIP
31	TRAIN PLATFORM																					
32	STRUCTURE PLATFORM		X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
33	ISOLATORS, SHOCK	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
34	BARBETTE																					
35	STRUCTURE, FRAME	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
36	STRUCTURE, EQUIP. PLATFORM		X	X	X	X	X		X							X		X	X		X	X
37	POWER SUPPLY, HYD.		X		X		X		X					X		X		X	X		X	X
38	CONTROL GROUP, ENVIRONMENT		X		X		X		X	X				X		X		X	X		X	X
39	SWITCHING MODULE		X		X		X		X					X		X		X	X		X	X
40	TRANSFORMER ASSY.		X		X		X		X					X		X		X	X		X	X
41	TRANSMITTER ASSY.		X		X		X		X					X		X		X	X		X	X
42	KLYSTRON		X		X		X		X					X		X		X	X		X	X
43	RATE SWITCH	X		X	X	X	X		X					X		X		X	X		X	X
44	ISOLATORS, SHOCK		X	X	X	X	X		X							X		X	X		X	X
45	ELECTRONICS ENCLOSURE																					
46	STRUCTURE ENCLOSURE	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
47	ISOLATORS, SHOCK	X		X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X
48	ISOLATORS, VIBRATION	X			X		X		X							X		X	X		X	X
49	SLIDES, DRAWER		X		X		X		X							X		X	X		X	X
50	EXCHANGER, HEAT	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
51	POWER SUPPLY, CONTROL GP		X		X		X		X			X		X		X		X	X		X	X
52	RU's		X		X		X		X			X		X		X		X	X		X	X

2

1

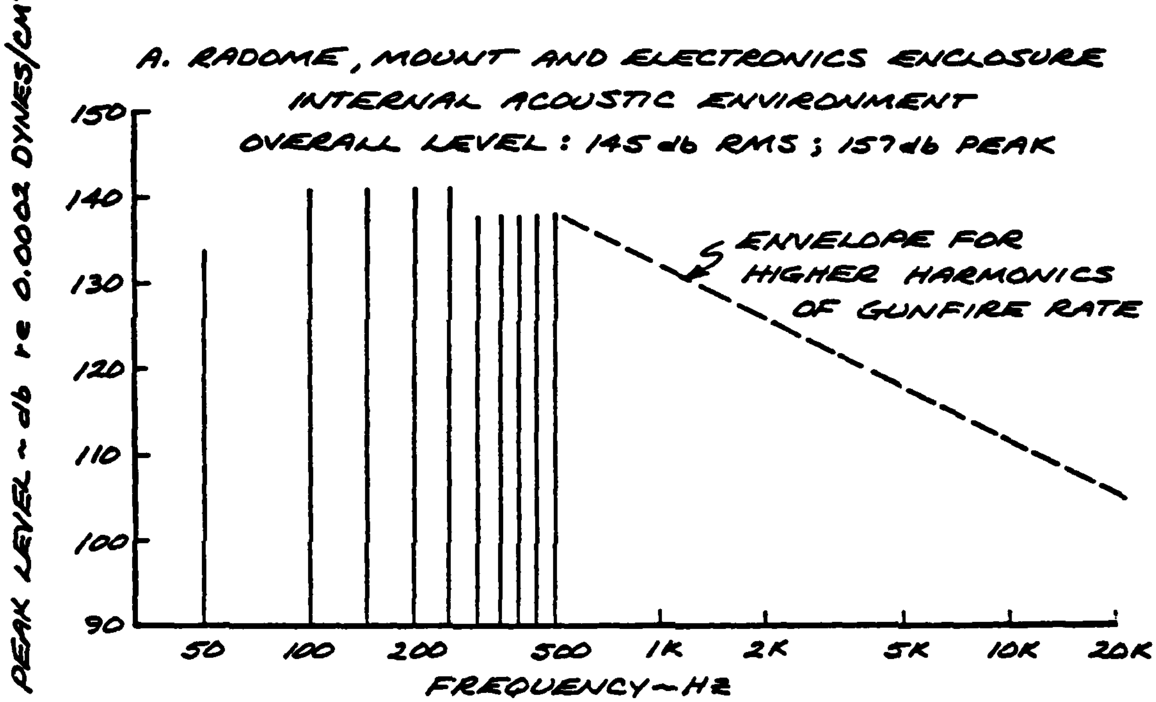
FIGURE 1 (CONT'D.)

RONMENTAL REQUIREMENT ALLOCATION MATRIX

	SHIPBOARD										CIWS														MISC.				
FOG	3.1 SHIPBOARD MAGNETIC	3.2 GUN BLAST	3.3.1 SHIP MOTION	3.3.2 SHIP INCLINATION—OPERATE	3.3.3 SHIP INCLINATION—SURVIVE	3.3.4 SHIP TURNING RATE	3.4 SHIP VIBRATION	3.5 WAVE LOADING	3.6 SEA STATE	3.7 SHIP INTERNAL TEMPERATURES	4.1 ACOUSTIC NOISE	4.2.1 25mm GUN ACOUSTICS	4.2.2 30mm GUN ACOUSTICS	4.3 35mm GUN VIBRATION	4.4 MOUNT MOTION	4.5 GUN RECOIL	4.6.1 MAX. TEMP.—OPERATE	4.6.2 MIN. TEMP.—OPERATE	4.6.3 WAVEGUIDE PRESSURIZATION	4.6.4 AIR HUMIDITY—OPERATE	4.6.5 AIR PRESSURIZATION	4.7 TRANSMITTER TEMP.	4.8 BARBETTE & MOUNT NON-CONTROLLED TEMP.	4.9 RADAR CONTROLLED TEMPERATURE	5.1 SHOCK LOADING	6.1 COMBINED LOAD—OPERATE	6.1 COMBINED LOAD—SURVIVE	7.0 BENCH HANDLING	8.0 TRANSPORTATION
							X																						
	X	X	X	X	X			X	X		X		X		X	X									X	X	X		
	X	X	X	X	X			X	X				X		X	X									X	X	X		
							X																						
	X	X	X	X	X			X	X		X		X		X	X									X	X	X		
	X		X	X	X				X		X		X												X				
	X		X	X	X				X		X	X		X									X		X				
	X		X	X	X				X		X	X		X									X		X				
	X		X	X	X				X		X	X		X								X			X				
	X		X	X	X				X		X	X		X								X			X				
	X		X	X	X				X		X	X		X					X			X			X				
	X		X	X	X				X		X	X		X								X			X			X	
	X		X	X	X	X			X		X	X		X											X			X	
	X		X	X	X				X		X	X		X											X				
							X																						
	X	X	X	X	X			X	X		X		X												X	X	X		
	X	X	X	X	X			X	X		X		X												X	X	X		
	X		X	X	X				X		X	X		X			X	X		X					X				
	X		X	X	X				X		X	X		X						X					X				
	X	X	X	X	X			X	X		X	X		X											X	X	X		
	X		X	X	X				X		X	X		X			X	X		X	X				X			X	
	X		X	X	X				X		X	X		X			X	X	X	X	X				X			X	

FIGURE 2

INTERNAL ACOUSTIC ENVIRONMENT
DUE TO 25mm GUN



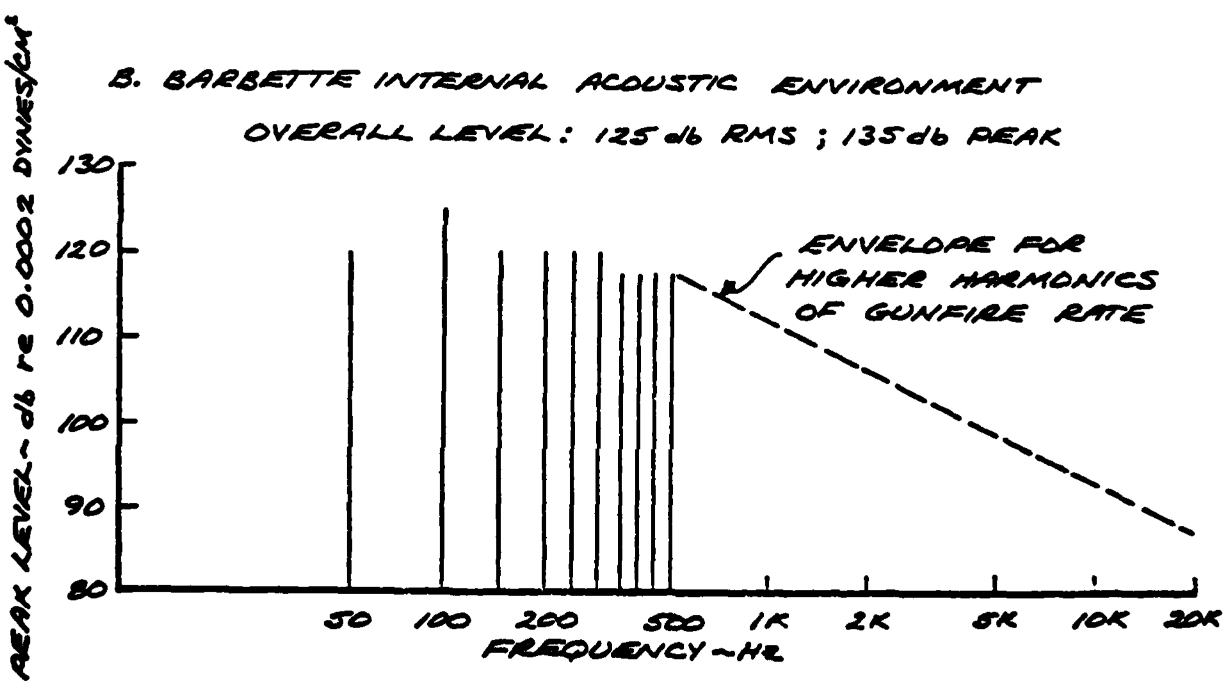


FIGURE 3
REFLECTED 30mm GUN BLAST PRESSURE
GAU-8, TP ROUND

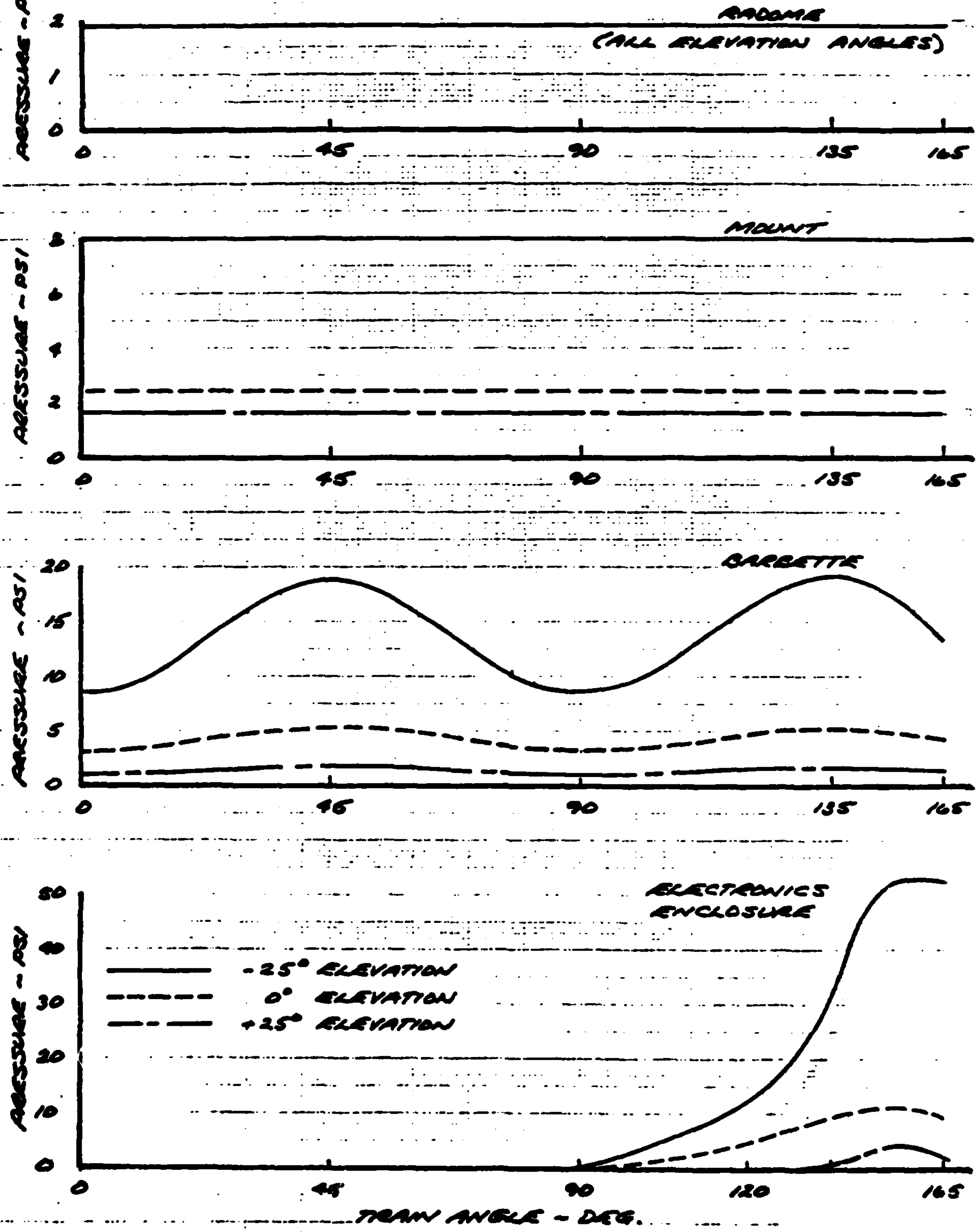


FIGURE 4

ACOUSTIC ENVIRONMENT INPUT FOR STRUCTURE FATIGUE ANALYSIS

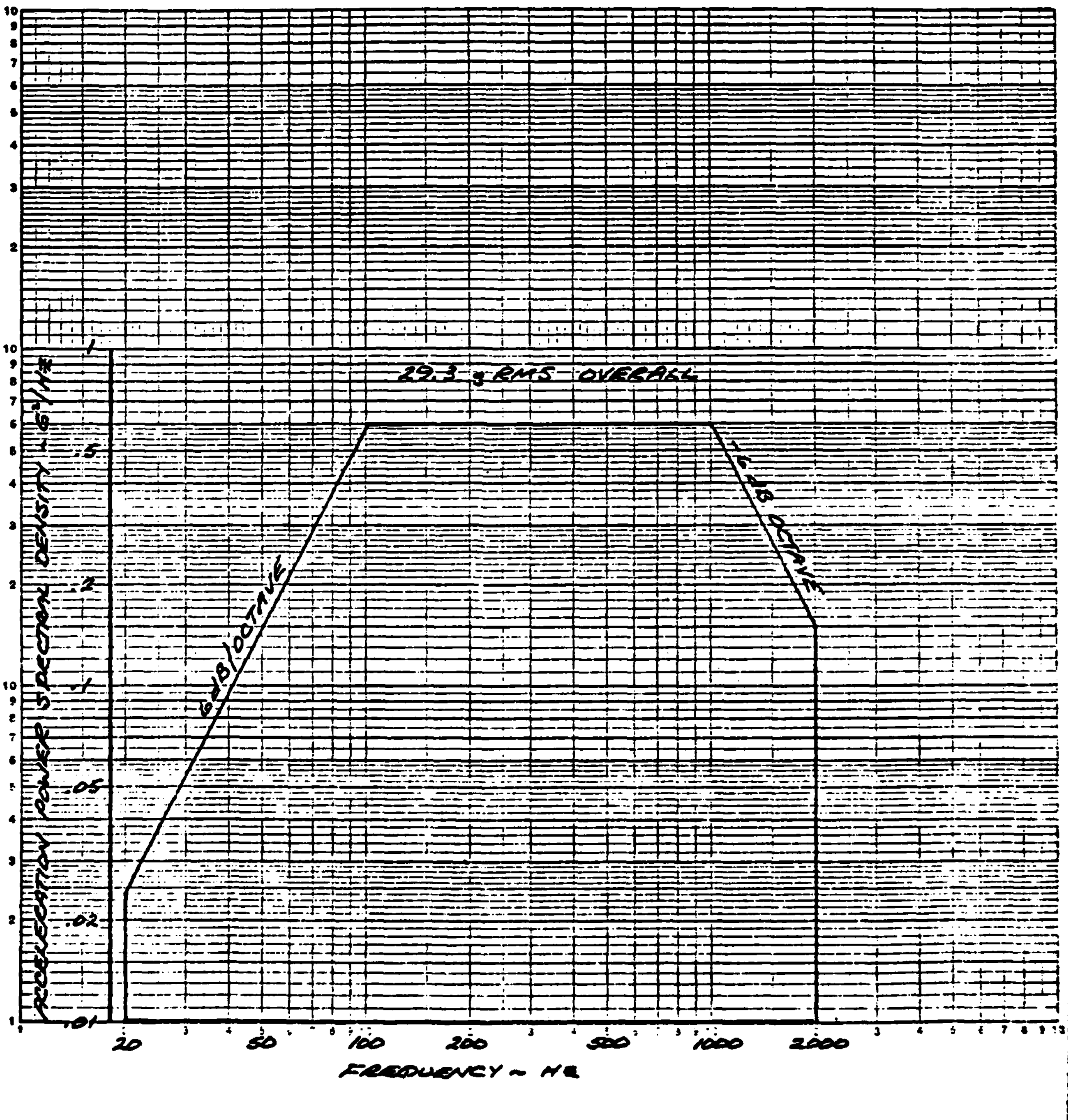
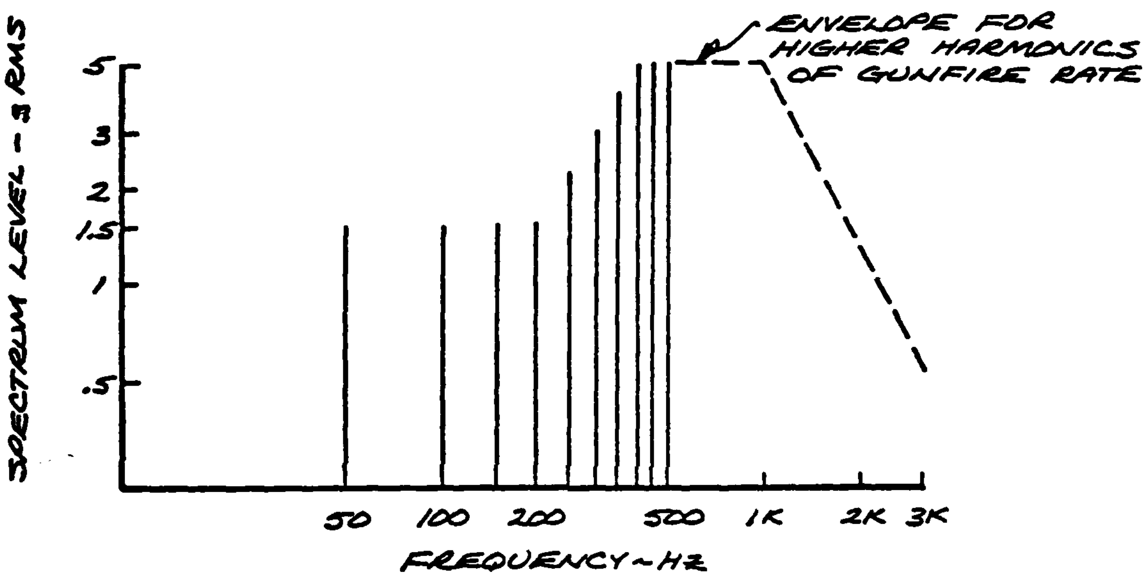


FIGURE 5

25mm GUN INDUCED ENVIRONMENTS

A. MOUNT INTERIOR VIBRATION
(NON-PROTECTED EQUIPMENT)

OVERALL LEVEL: 15 g RMS; 50 g PEAK



B. RADOME AND ELECTRONICS ENCLOSURE INTERIORS
(NON-PROTECTED EQUIPMENT)

OVERALL LEVEL: 12 g RMS ; 40 g PEAK

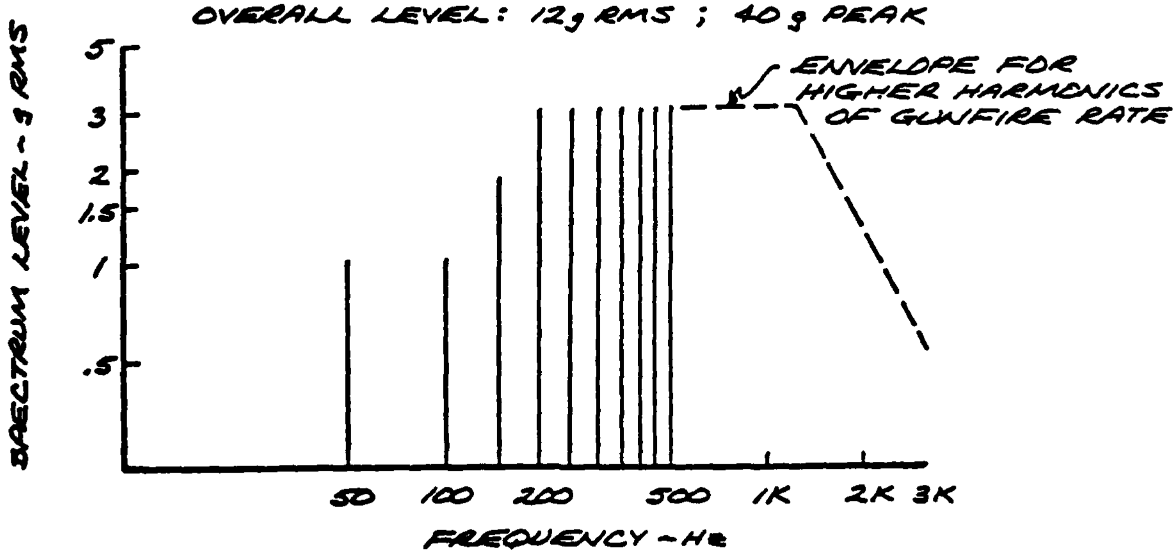
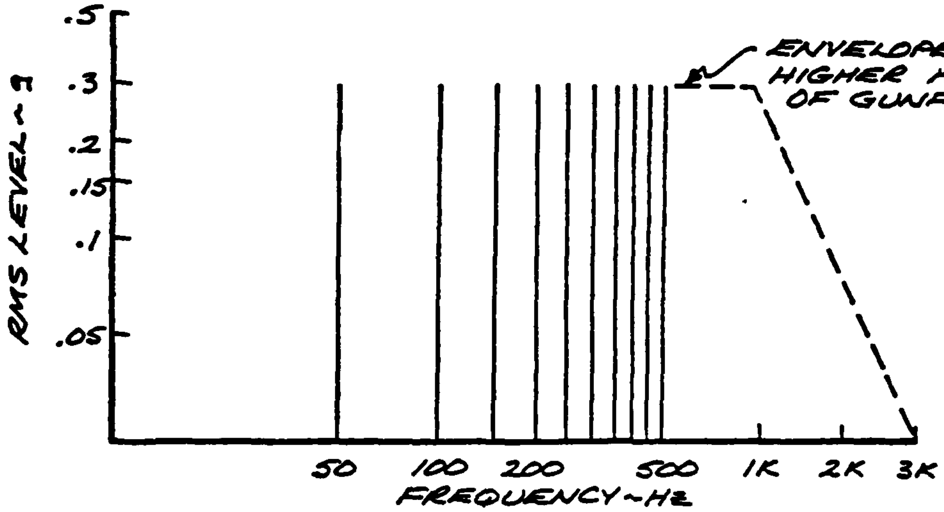


FIGURE 5 (CONT.)

25mm GUN INDUCED ENVIRONMENTS

C. ISOLATED PACKAGES IN RADOME (25Hz ISOLATION)

OVERALL LEVEL: 2g RMS; 7g PEAK



D. BARBETTE EQUIPMENT PLATFORM VIBRATION (10 Hz ISOLATION)

OVERALL LEVEL: 1g RMS; 3.5g PEAK

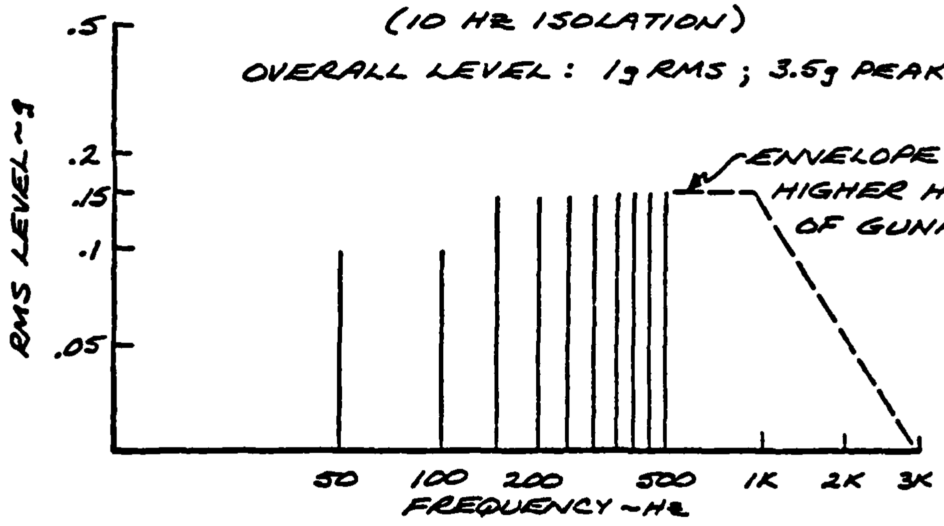
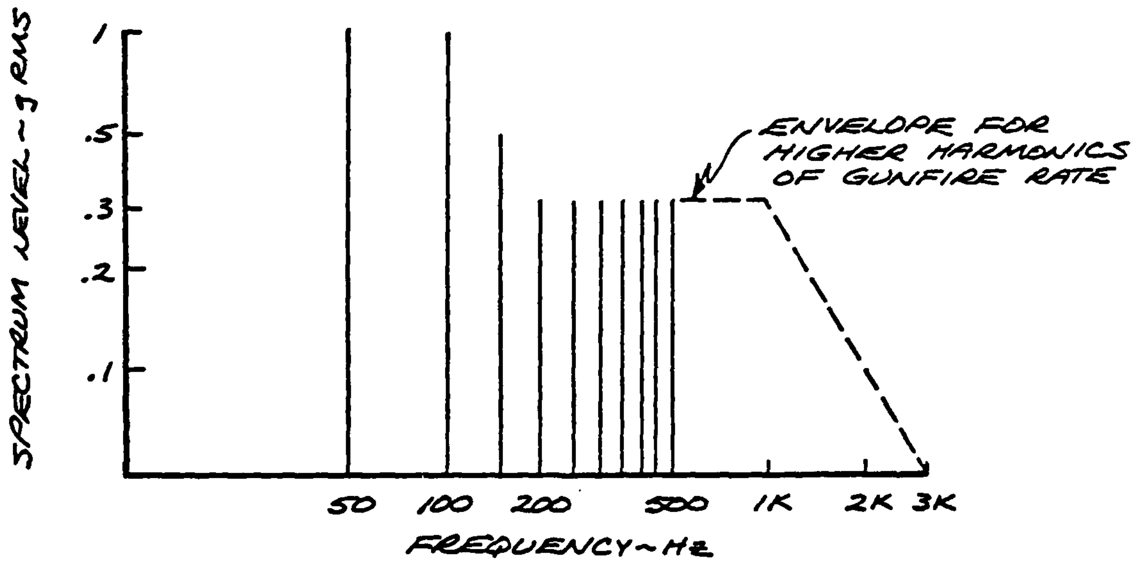


FIGURE 5 (CONT.)

25 mm GUN INDUCED ENVIRONMENTS

E. ISOLATED PACKAGES IN ELECTRONICS ENCLOSURE
(25 Hz ISOLATION)

OVERALL LEVEL: 2.2 g RMS ; 7 g PEAK



Appendix A

ENVIRONMENTAL TEST CONDITIONS AND TEST METHODS

Environmental qualification of hardware is to be performed using military standard tests for all critical items. At the subsystem and system level some special tests are required in addition to the military standard tests. Tables A-I and A-II provide a list of the test methods to be used in critical item and subsystem specifications for environmental qualification for the non-operating and operating conditions.

Table A-III provides the test conditions and test methods for performing shock, vibration and acoustic testing. The test conditions take into account the dynamic environments from all sources. Test conditions depend on equipment location and on the presence or absence of vibration isolators. Table A-III indicates the appropriate levels according to this criteria.

Table A-IV provides a summary of the design temperatures throughout the system. A

Table A-1

NON-OPERATING ENVIRONMENTAL TEST METHODS PER MIL-STD-810C

Environment	DI-444-A-002 Reference	Test Method: Critical Item	Test Method: Subsystem	Test Method: System	Notes
Low Temp	2.1 b	503.1 (Low Temp and High Temp)	502.1	502.1	Min. Temp = -40°C
High Temp	2.2 b		DI Duty Cycle	DI Duty Cycle	Max Temp = 71°C
Humidity	2.4	507.1, Proc.IV	507.1	—	
Blowing Particles	2.7 b	510.1	510.1	—	
Atmospheric Pressure	2.8	500.1	—	—	Min Pressure 1.68 psi Operation not required at low pressure
Rain	2.9	—	—	*	Max Rate = 7 IN/HR
Fungus	2.10	508.1**	508.1**	—	
Salt Fog	2.12	509.1	509.1	—	Enclosures: 5% for 200 HR Interior: 5% for 48 HR***
Combined Survival Loads	6.2	*	*	*	Loading per: 2.6, 2.11, 3.3, 3.5 of DI-44-A-002
Bench Handling	7.0	516.2, Proc.V	—	—	
Transportation	8.0	5.4.2, Proc. X	—	—	Gun vibration qualifies for transporation also

* Special Test Plan Required.

** Test only when materials do not meet the requirements of MIL-STD-454 and when directed by Program Office.

*** No test required when item is housed by 2 or more enclosures.

Table A-II

OPERATING ENVIRONMENTAL TEST METHODS

Environment	1-444-A-002 Reference	Test Method			Notes
		Critical Item	Subsystem	System	
Low Temp	2.1 a	502.1	502.1	502.1	MIL-STD-810C Omit Steps 2 & 3
High Temp	2.2 a	501.1, Proc.I	501.1, Proc. I	DI Duty Cycle	Omit Steps 2 & 3
Solar Radiation	2.3	—	—	—	
Sea Temp	2.5	—	*	*	
Rain	2.9	—	—	*	
Magnetic Conditions	3.1	—	—	*	
Gun Blast	3.2	—	—	*	
Ship Motion	3.3	—	—	*	
Ship Vibration	3.4	—	MIL-STD-167B	MIL-STD-167B	
Acoustic Noise	4.1	MIL-STD-740	MIL-STD-740	MIL-STD-740	
Gun Acoustics	4.2	Method 515.2	Method 515.2	Method 515.2	MIL-STD-810C Max level per DI-444-A-002
Gun Vibration	4.3	Method 514.2	Method 514.2	Method 514.2	MIL-STD-810C Max level per DI-444-A-002
Mount Motion	4.4	—	*	*	
Shock Loading	5.2	MIL-STD-810C Method 516.2	MIL-STD-810C Method 516.2	MIL-STD-901C	Max level per DI-444-A-002
Combined Loading	6.1	*	*	*	Loads per 2.6, 2.11, 3.3, 4.5

*Special Test Plan Required

A

Table A-III

SHOCK, VIBRATION AND ACOUSTIC TEST CONDITIONS FOR CIWS PACKAGE

A. OPERATING

Environment and Method	Package Location and Type of Mounting						
	Radome		Mount or Platform	Barbette	Elect. Enclosure		Local & Remote Control Panels
	25 Hz(1) Isolated	Non Protected	Hard Mounted	(10 Hz(1) Isolation)	25 Hz(1), Isolated	Non Protected	Isolated
Shock MIL-STD-810C Method 516.2	Procedure I 40g Half-Sine 11 m-Sec	Procedure IV 100g Sawtooth 6 m-Sec	Procedure IV 100g Sawtooth 6 m-Sec	Procedure III 30g Half-Sine 11 m-Sec	Procedure I 40g Half-Sine 11 m-Sec	Procedure IV 100g Sawtooth 6 m-Sec	Procedure I 40g Half-Sine 11 m-Sec
Vibration MIL-STD-810C Method 514.2	Procedure VII Condition N (2g Peak) Condition AE (5.4g RMS)	Procedure V Condition P (5g Peak) Condition AH (12g RMS)	Procedure V Condition P (5g Peak) Condition AJ (16.9g RMS)	Procedure VII Condition N (2g Peak) Condition AE (5.4g RMS)	Procedure VII Condition N (2g Peak) Condition AE (5.4g RMS)	Procedure V Condition P (5g Peak) Condition AJ (16.9g RMS)	Procedure VII Condition N (2g Peak) Condition AE (5.4g RMS)
Acoustic MIL-STD-810C Method 515.2 Procedure I	(3) (145 db(2), 30 min.)	Category C (160 db(2), 8 min)	Category C (160 db(2), 8 min.)	Category B (150 db(2), 30 min)	Category B (150 db(2), 30 min.)	Category C (160 db(2), 8 min.)	Category A 140 db(2), 30 min.

1. Environment applicable at package side of isolator. Use test condition in first column if the normally isolated package is tested without isolators. The input to the isolators is the non protected environment of the second column.
2. Reference 0.0002 dynes/cm^2.
3. 130 db inside receiver housing.

B. NON-OPERATING

ENVIRONMENT	TEST CONDITION(1)
Shock (Bench Handling)	MIL-STD-810C, Method 516.2, Procedure V (Edge lifted 4 inches and dropped on wooden bench top for total of 24 drops)
Vibration (Transportation)	MIL-STD-810C Method 514.2 Procedure X, Curve AW(1.5g) or .3 in P-P. (Resonance dwell and sinusoidal cycling for a total test time of 1 hour per axis)

1. The non-operating test condition does not depend on location within the system.
2. Transportation not required when operating vibration (gun vibration) test is performed.

Table A-IV

TEMPERATURE ENVIRONMENTS FOR CIWS PACKAGES

OPERATION	TEST METHOD (MIL-STD-810C)	PACKAGE LOCATION					
				BARBETTE			
		RADAR SERVO STRUCTURE	MOUNT AND PLATFORM	UNCONTROLLED	TRANSMITTER & POWER SUPPLY	ELECTRONICS ENCLOSURE	LOCAL & REMOTE CONTROL PANELS
Non-Operating	503.1 Duration: 3 cycles of 4 hrs. each or until stabilized.	-40 to 71°C (-40 to 160°F)	-40 to 71°C (-40 to 160°F	-40 to 71°C (40 to 160°F)	-40 to 71°C (-40 to 160°F)	-40 to 71°C (-40 to 160°F)	-40 to 71°C (-40 to 160°F)
Operating							
LOW	502.1 (Omit Steps 2 & 3)	4°C	-29°C	-29°C	46°C	4°C	0°C
	Duration: Until temp. is stabilized.	(39°F)	(-20°F)	(-20°F)	(115°F)	(39°F)	(32°F)
HIGH	501.1, Procedure I (Omit Steps 2 & 3)	66°C	66°C	66°C	66°C	62°C	50°C
	Duration: Until temp. is stabilized	(150°F)	(150°F)	(150°F)	(150°F)	(144°F)	(122°F)

APPENDIX M

CDRL A003
Code Ident 0543
M-24-6-866

APPENDIX M

DEVELOPMENT PROCESS SPECIFICATION (D.P.S.) FOR INJECTION MOLDED FILTER

SUBJECT: Fabrication of the Injection Molded S-13 Filter
P/N 5188423.

1.0 SCOPE

This DPS defines an improved process for manufacturing the S-13 Filter by the use of injection molding techniques.

2.0 PURPOSE

This DPS is written to provide a simplified process for injection molding high strength glass filled thermoplastic into the configuration required and to afford an outline for the preparation of a future MPS for production requirements.

3.0 PROCEDURE

3.1 INJECTION MOLDING PREPARATIONS

3.1.1 The plastic molding compounds must be dried prior to it's use. General Electric "Valox" 420-SEO (Blue), PN 602-800-196 is placed in drying trays to a depth of 1" and dried at 250°F ± 10°F for a minimum of 4 hours and a maximum of 48 hours.

Note: Material dried for longer than 48 hours shall be discarded.

3.1.2 The injection molding press shall be set-up and adjusted by or under the direct supervision of Department 24-6 personnel.

3.1.3 Adjust the temperature controllers to the following temperatures,

Front Zone 490°F ± 5°F
Rear Zone 480°F ± 5°F
Nozzle Zone 500°F ± 5°F

3.1.4 Turn on electrical power to the injection molder; after the barrel reaches the set temperature adjust the following pressures,

Boost Pressure 1500 psig
Hold Pressure 1100 psig

3.1.5 Adjust the following controls,

Cycle Time	60 sec ± 0.2 sec	- All parts
Injection Time	30 sec ± 0.2 sec	- Cavity and cover
	14 sec ± 0.2 sec	- End cap
Boost Time	2.0 sec ± 0.2 sec	- All parts
Shot Size	2.0 oz ± 0.1 oz	- Cavity
	1.25 oz ± 0.1 oz	- Cover
	0.5 oz ± 0.1 oz	- End cap
Injection Speed	Maximum Speed	- All parts
Screw Speed	4:1	- All parts
Back Pressure	18 Threads exposed	- All parts

3.1.6 Fill the hopper with one tray if dried material. Do not load the hopper with more than one tray at a time.

3.1.7 Purge the machine until all foreign material or undried "Valox" has been removed.

3.1.8 Allow the barrel to return to the proper temperature before proceeding.

3.2 <u>INJECTION MOLDING OF WAVEGUIDE COVER CAP</u>

3.2.1 Load the cover of the mold, #24-6-100, with (8) 10-56 inserts, MS 51836-101, using 0.590" long 10-56 screws to hold them in place. These screws are made using 0.610" long 10-56 screws.

3.2.2 Purge the machine until all air popping has been eliminated and allow the machine to complete extrusion.

3.2.3 Remove any foreign matter from the mold using compressed air. Assemble mold sections together and place the mold assembly in the injection molder ensuring fill hole alignment with sprue bushing.

3.2.4 Wait 30 sec to allow full heating of the plastic. Using a manual short shot to purge out any accumulation of air, extrude and move injector carriage forward to the stationary platen.

3.2.5 With the machine in the semi-automatic mode, close the safety gate to initiate the machine cycle. After completion of the injection cycle, but prior to the completion of the total cycle, switch from the semi-automatic to the manual mode. Allow the mold to cool for two minutes with the press closed. Return injector carriage to the rear position.

3.2.6 Remove waveguide cover mold from machine. Remove eight screws holding the inserts. Separate cover and base plate from center plate. Place center plate in a 50 ton Hull press with posts facing up. Support each end with 2" aluminum blocks. Place ejector, posts down, onto the tips of the molded posts and slowly eject cover out of the mold.

Note: B Should the mold not fill, or the part have excess flash, dimples, or any other defects, the mold and machine conditions shall be verified by Dept. 24-6.

3.2.7 Place molded cover aside for post molding operations. Repeat steps 3.2.1 through 3.2.7.

3.3 INJECTION MOLDING OF WAVEGUIDE CAVITY

Note: C Preparation and control settings are identical to the waveguide cover cap with the exception of the platen separation and shot size.

3.3.1 Adjust shot size to 2.0 oz.

3.3.2 The injection molding press shall be set-up and adjusted by or under the direct supervision of Department 24-6 personnel.

3.3.3 If the mold is already assembled loosen eight Allen screws attached to the end blocks before removing the mold cover. Remove cover. Load the cover of the waveguide cavity mold with (14) 10-56 inserts using 0.61" long 10-56 screws to hold them in place.

3.3.4 Purge the machine until all air popping has been eliminated and allow the machine to complete extrusion.

3.3.5 Remove any foreign matter from the mold using compressed air.

3.3.6 Assemble mold cover to base and attach end blocks. Secure with eight Allen screws.

3.3.7 Position the runner plate over the mold cover ensuring correct draft angle and alignment with runners. Position sprue plate over runner plate.

3.3.8 Place mold assembly in injection molder, ensuring fill hole alignment with sprue bushing.

3.3.9 Using a manual short shot purge out any accumulated air, extrude, and move injector carriage forward to the stationary platen.

3.3.10 With the machine in the semi-automatic mode, close the safety gate and start the machine cycle. After completion of injection, but prior to completion of the total cycle, switch from the semi-automatic to the manual mode. Allow the mold to cool for two minutes with press closed. Return injector carriage to rear position.

3.3.11 Remove waveguide cavity mold from machine. Remove sprue and runner plates. Remove 14 screws holding inserts. Loosen eight Allen screws holding end blocks to mold base. Remove end blocks.

3.3.12 Place mold assembly, cover side up, in a Hull press with the cover ends supported by 2" aluminum blocks. Place four 0.250" dowels into the mold cover holes. Place a rubber cushion under the mold base.

3.3.13 Turn the closure rate to the slow close setting. Close the press and separate the mold cover from the mold base. Remove the mold base and open press.

3.3.14 Place four 0.085" dia 1.75" long pins into the end insert holes.

3.3.15 Close the press again and eject the waveguide cavity off the mold core.

Note: D Should the mold not fill or the part have excess flash, dimples, or any other defects; the mold and machine conditions shall be verified by Dept. 24-6.

3.3.16 Place the molded waveguide cavity aside for post molding operations. Repeat steps 3.3.3 through 3.3.16.

3.4 INJECTION MOLDING OF END CAP

Note: E Preparations and control settings are identical to the waveguide cavity with the exception of the platen separation, shot size, and injection time.

3.4.1 Adjust shot size to 0.5 oz and injection time to 14 seconds.

3.4.2 The injection molding press shall be set-up and adjusted by or under the direct supervision of Department 24-6 personnel.

3.4.3 Separate mold cover from mold base.

3.4.4 Remove any foreign matter from the mold using compressed air.

3.4.5 Assemble mold cover to base and place mold assembly in injection molder ensuring fill hole alignment with sprue bushing.

3.4.6 Use a manual short shot to purge out any accumulated air, extrude and move injector carriage forward to the stationary platen.

3.4.7 With the machine in the semi-automatic mode, close the safety gate and start the machine cycle.

3.4.8 After completion of the total cycle open the safety gate and remove the mold assembly.

3.4.9 Separate the mold cover from the base using a small screwdriver.

3.4.10 Remove the molded end cap from the mold cavity by gripping the sprue with a pair of pliers.

Note: F Should the mold not fill, or the part have excess flash, dimples, or any other defects, the mold and machine conditions shall be verified by Department 24-6.

3.4.11 Place the molded end cap inside for post molding operations. Repeat steps 3.4.4 through 3.4.11.

3.5 POST MOLDING OPERATIONS

3.5.1 Carefully cut off all gates and runners with a band saw.

3.5.2 Temperature stabilize all molded parts by baking at 160°F ± 5°F for a minimum of 16 hours. Waveguide cavities shall be restrained with thermal stabilization fixture P/N 24-6-103.

3.5.3 A pair of waveguide cavities are then baked while restrained with the thermal inner stabilization fixture P/N 24-6-104, and the two outer plates fixture P/N 24-6-107 for four hours at 160°F ± 5°F.

3.5.4 Remove restraining clamps, leave the cavities and aluminum block assembled and bake for two hours minimum at 160°F ± 5°F.

3.5.5 Use a file to blend the gate flush with the molded plastic. Use #240 and #400 sandpaper to further smooth the gate area.

3.5.6 Insert drill fixture P/N 24-6-102 into the waveguide cavity and clamp total assembly together with two Allen screws.

3.5.7 Drill 13 tuning screw holes with a #19 drill. Do not drill the input-output posts.

3.5.8 Insert a 0.25" 41° countersink into a hand tap fixture. Set the fixture depth to cut a 0.205" wide countersink on the previously drilled holes. Countersink both sides of each hole.

3.5.9 Insert a 0.190" -64 NS tap into the hand tap fixture. Tap 13 tuning screw holes.

3.5.10 Insert the input-output post drill fixture, P/N 24-6-105, into the waveguide cavity and over the post. Drill the posts with a #62 drill and remove any burrs.

3.5.11 Tap both holes to a depth of 0.25" with a 1.2 x 102 metric tap.

3.5.12 Drill 14 waveguide cover holes with a #13 drill. Use the molded in countersinks to position the drill. Lightly countersink both ends of all holes.

3.5.13 Drill eight end cap holes into the waveguide cavity and cover using a template. Countersink and tap with a 2-56 tap to a depth of 0.37" minimum.

3.5.14 Drill four thru holes into the end caps using a #39 drill. Use the mold markings to align the drill.

3.5.15 Remove all flash and burrs from the molded parts using a Scotch Brite type A extra fine pad. Areas to be scrutinized are the part edges and post tips.

3.5.15 Thread a tuning screw through all 13 tuning screw holes to remove all burrs.

3.6 METALLIZATION OF THE INJECTION MOLDED S13 FILTER

3.6.1 Vapor hone thoroughly using 0.75 silica blend grit. (20% by weight slurry).

3.6.2 Thoroughly rinse in running water for two minutes @75^{o}F.

3.6.3 Ultrasonically clean in deionized water for five minutes @75^{o}F.

3.6.4 Immerse in MacDermid 9076 cleaner/conditioner for ten minutes @150^{o}F.

3.6.5 Running water rinse for two minutes @75^{o}F (D. I. Preferred).

3.6.6 Immerse in 50% (by volume) HNO_3 for five minutes @75^{o}F.

3.6.7 Running water rinse for two minutes @ 75^{o}F. (D.I. Preferred).

3.6.8 Immerse in 10% (by volume) HF for seven and one half minutes @75^{o}F.

3.6.9 Running water rinse for two minutes @75^{o}F (D.I. Preferred).

3.6.10 Immerse in 20% (by weight) NaOH for two minutes @75^{o}F.

3.6.11 Running water rinse for two minutes @75^{o}F (D.I. Preferred).

3.6.12 Ultrasonically clean in deionized water for five minutes @75^{o}F.

3.6.13 Mask alignment pins and holes on the waveguide cap and cavity respectively.

3.6.14 Immerse in MacDermid 9076 cleaner/conditioner for ten minutes @150^{o}F.

3.6.15 Rinse in deionized water for two minutes @75^{o}F.

3.6.16 Immerse in Shipley Cataprep 505 for five minutes @75^{o}F.

Note G: Do Not Rinse.

3.6.17 Immerse in 3% (by volume) Shipley Cataposit 44 for five minutes @110^{o}F.

3.6.18 Rinse in deionized water for two minutes @75^{o}F.

3.6.19 Remove masking on alignment pins and holes.

3.6.20 Immerse in Shipley Accelerator 19 for five minutes @75^{o}F.

3.6.21 Rinse in deionized water for one minute @75^{o}F.

3.6.22 Immerse in Shipley CP-70 electroless copper for three and five hours, cap and cavity, respectively @110^{o}F. (Bath loading shall be 42 in^2/gal of solution.)

3.6.23 Polish with Scotch Brite Type A extra fine pad to remove any oxidation or nodulation.

3.6.24 Immerse in Dynachem LAC 41 acid copper cleaner for one minute @150^{o}F.

3.6.25 Running water rinse for two minutes @ 75^{o}F.

3.6.26 Immerse in electrolytic acid gold plating tank for fifteen minutes @75^{o}F. (Bath loading shall be twenty-five amperes/Ft^2.)

3.6.27 Running water rinse for two minutes @75^{O}F.

3.7 INJECTION MOLDED FILTER ASSEMBLY

3.7.1 Fasten waveguide cover to waveguide cavity with 14 screws and flat washers. Torque to 4in-lbs.

3.7.2 Thread two connector pins into the input and output posts. Gauge the pins heights above the waveguide cover to 0.300" $\pm$ 0.010".

3.7.3 Cut two teflon dielectrics to the proper height and engage over connector pins. The top of the teflon must be flush with the pin tip.

3.7.4 Assemble two connectors over the teflon dielectric and fasten with eight screws and lock washers. Torque to 3in-lbs.

3.7.5 Insert 13 tuning screws. Check for complete travel through the waveguide.

3.7.6 Place two end caps over the filter assembly. Fasten with eight screws and torque to 2in-lbs.

4.0 MATERIALS

Valox 420SEO	602-800-196
Insert	MS 51836-101
Screw	MS 35206-208
Washer	MS 27183-2
Connector	#2052-1200
Tuning Screw	
75 Silica Blend Grit	000-535-013
Nitric Acid	
Hydrofluoric Acid	
Sodium Hydroxide	
Shipley Cataprep 505	
Shipley Cataposit 44	
Shipley Accelerator 19	
Shipley CP-70 Electroless Copper System	
3M Scotch Brite Finishing Pad	000-535-024
Glass Wool (Coarse)	

5.0 EQUIPMENT AND TOOLING

Injection mold, waveguide cavity	PN 24-6-101
Injection mold, waveguide cover	PN 24-6-100
Injection mold, waveguide end cap	PN 24-6-106
Tuning screw drill fixture	PN 24-6-102
Drill fixture input-ouput posts	PN 24-6-105
Body annealing-fixture	PN 24-6-103
Body annealing fixture	PN 24-6-104
Fixture	PN 24-6-107

Tap 1.2 x 102 metric
Tap 0.190" x 64
Tap 2-56
Countersink 0.250" - 41^{o}
Drills #13
Drills #19
Drills #39
Drills #62

Files
Screwdrivers
Allen wrenches
Drill Press
Injection molding press, Newbury 150 Ton-6 oz shot size
Hull Press - 50 Ton
Four liter beakers
Nylon anode bag
Air driven magnetic stirrer
Thirty liter beakers
Glass stirring rod
Heating plate
Copper wire
Tygon tubing 0.439" OD and 0.391" OD
Peristaltic pump
Masking dowels and sleeves
Graduated cylinder (0.5 liter)
Air agitation fixture
Vapor honing apparatus

6.0 QUALITY ASSURANCE PROVISIONS

When surveillance of the process defined in this DPS, or inspection of the product indicates that the stipulation of this DPS have not been complied with, acceptence shall be withheld until operations and Quality Assurance Departments concur that the engineering and reliability requirements have not been compromised.

7.0 SAFETY

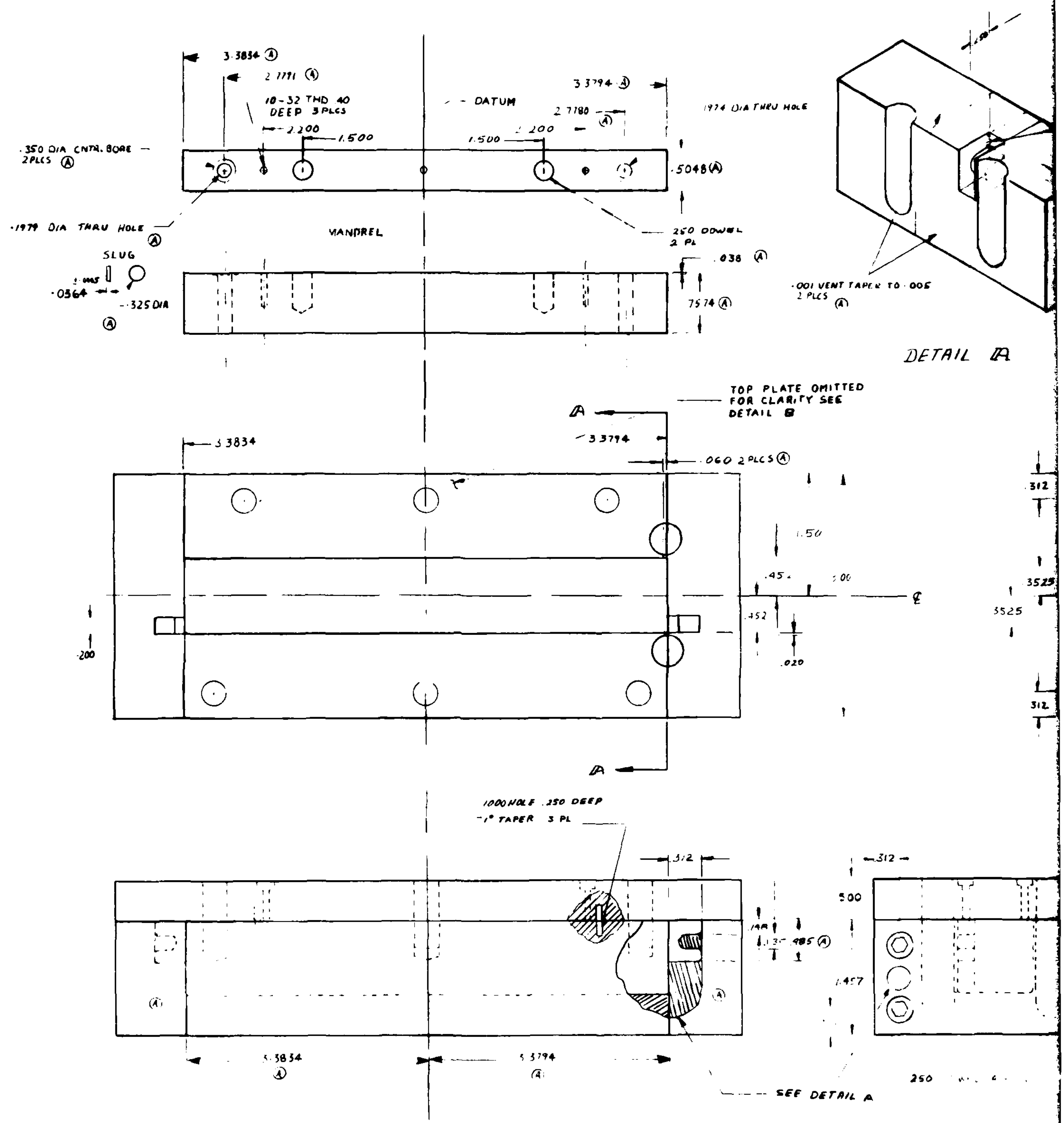
Comply with all Pomona Division and OSHA Safety precautions required for use with flammable materials fabrication.

APPENDIX N

CDRL A003
Code Ident 0543
M-24-6-866

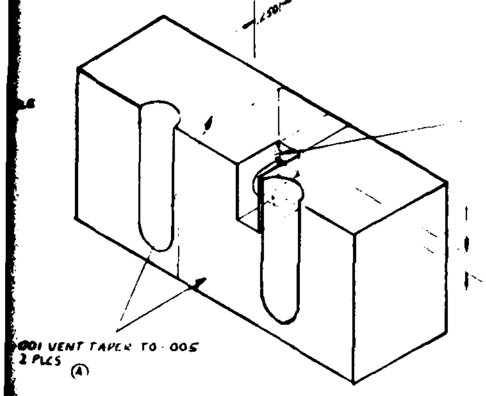
APPENDIX N

INJECTION MOLDED FILTER - TOOLING MOLD DRAWINGS AND FORMAL DRAWINGS

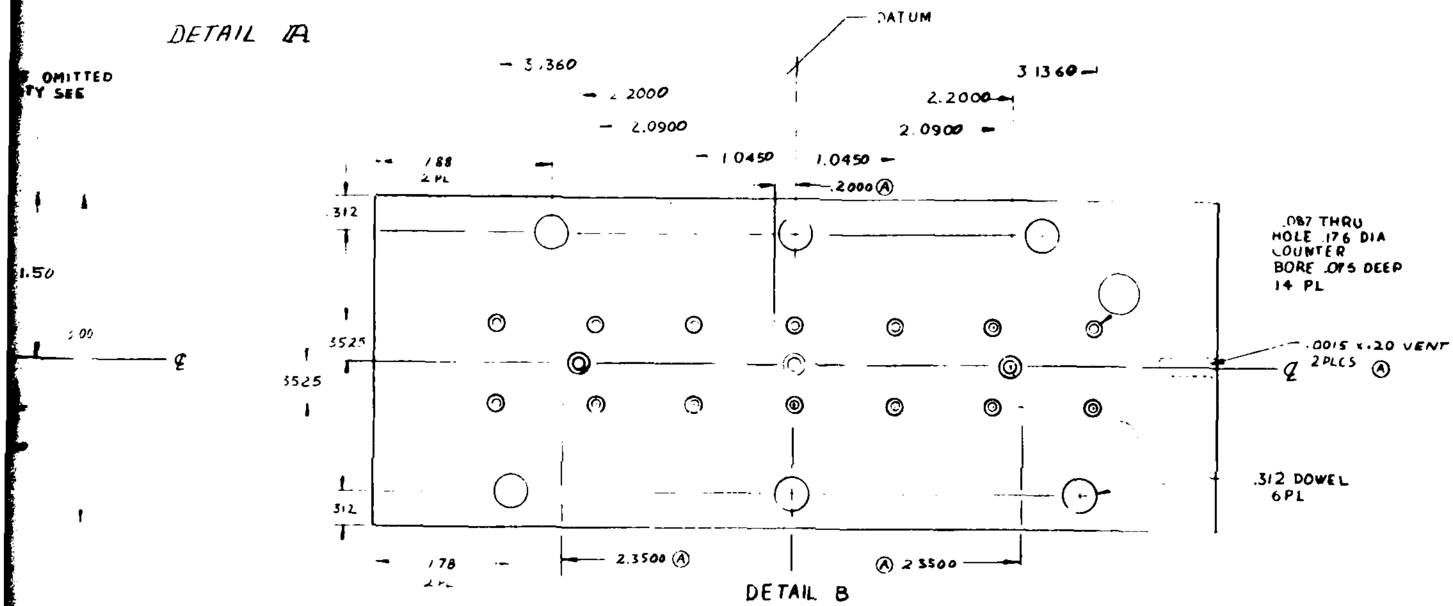


CAVITY FINISH — POLISH SP

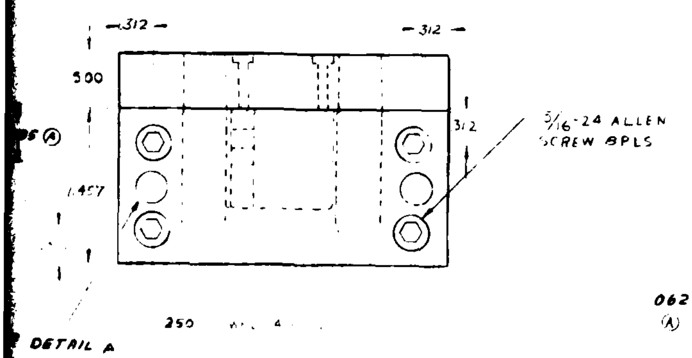
2

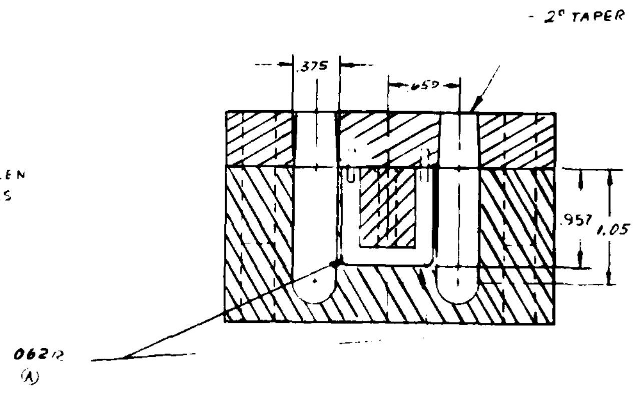


DETAIL A



DETAIL B



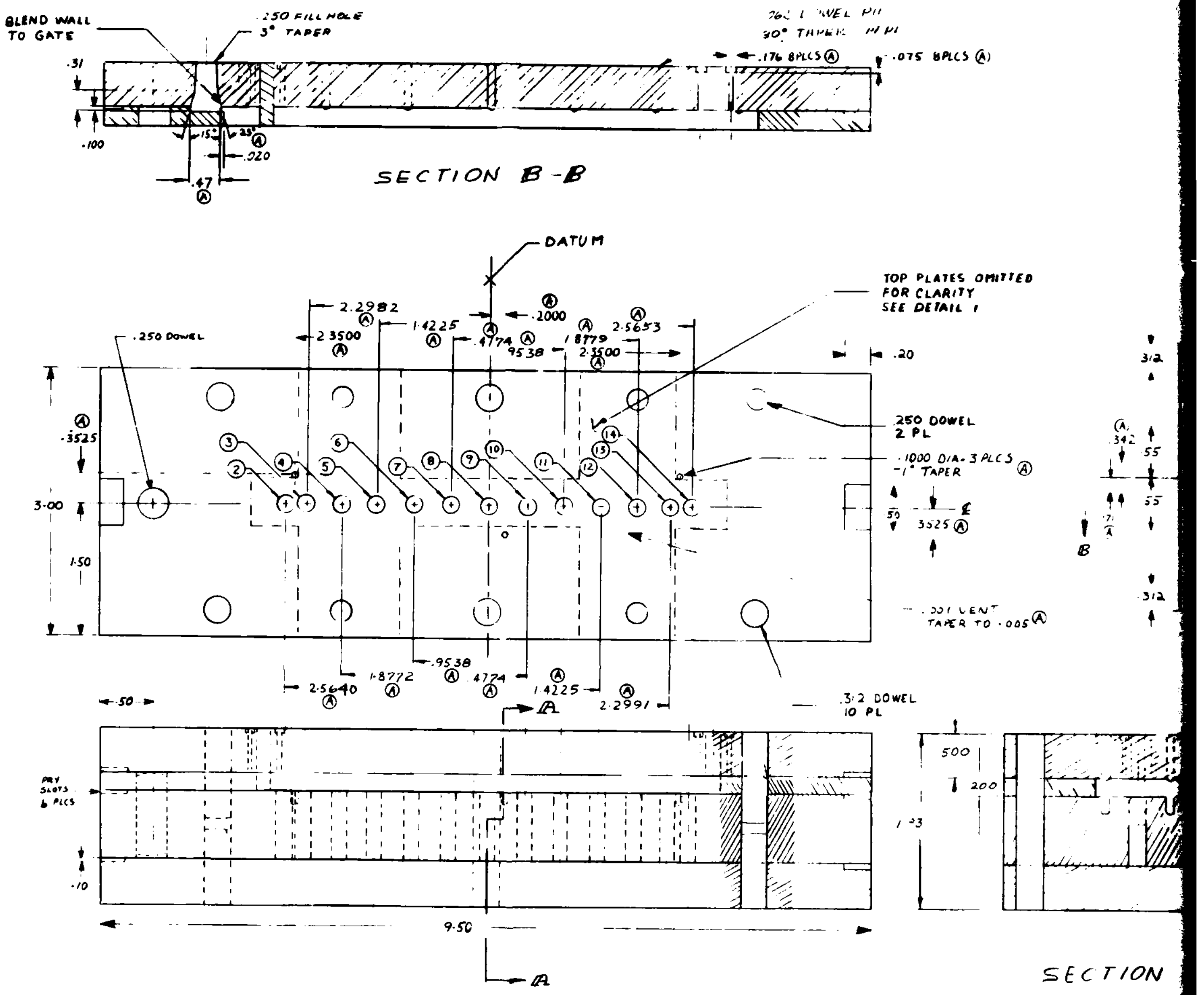


SECTION A-A

FINISH — POLISH SP 3

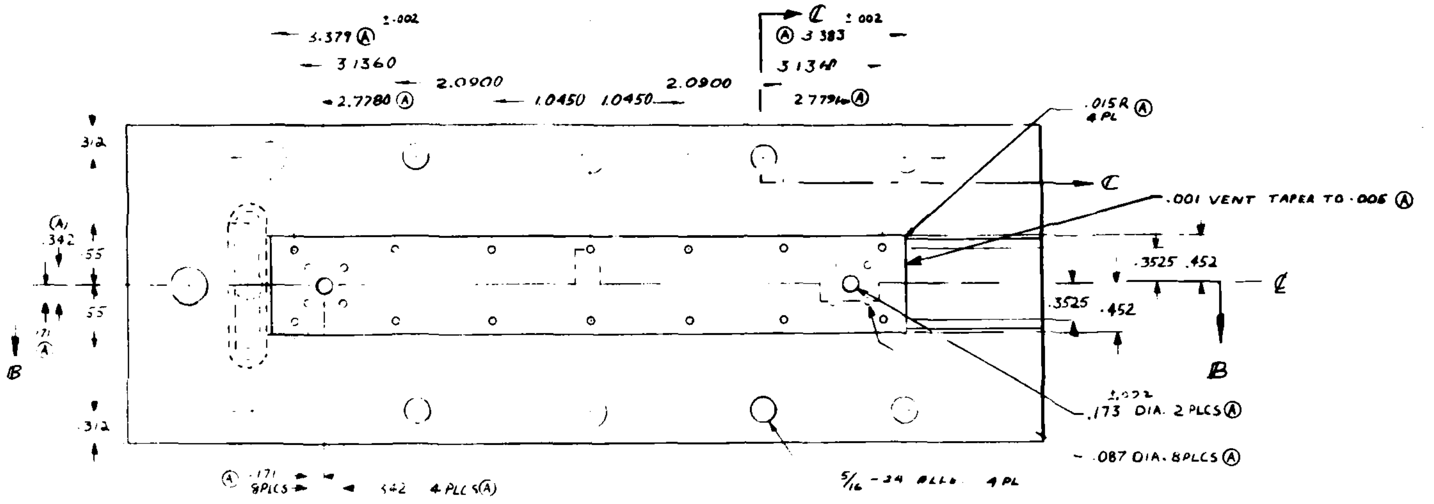
DIMENSION TOLERANCES .XXXX ±.0002 .XXX ±.005 .XX ±.010	CAVITY MOLD	
	WAVEGUIDE CAVITY S-13 FILTER	
ENGR. W L McT… DRAWN SIMS 9/2/79		
MATERIAL 440C STAINLESS STEEL 52-54 R	REVISION A	24 6-101
	SCALE 3/2	SHEET 1 OF 2

PRECEDING PAGE BLANK-NOT FILMED

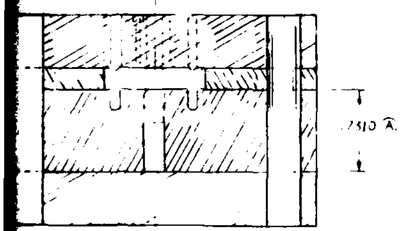


NO	HOLE DIA (A)
2	.1501
3	.1807
4	.1877
5	.1920
6	.1937
7	.1948
8	.1958
9	.1951
10	. 937
11	.1920
12	.1877
13	.813
14	.507

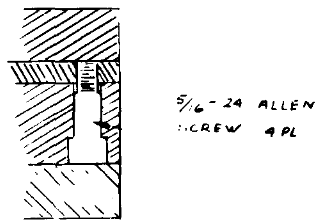
2



DETAIL 1



SECTION A-A



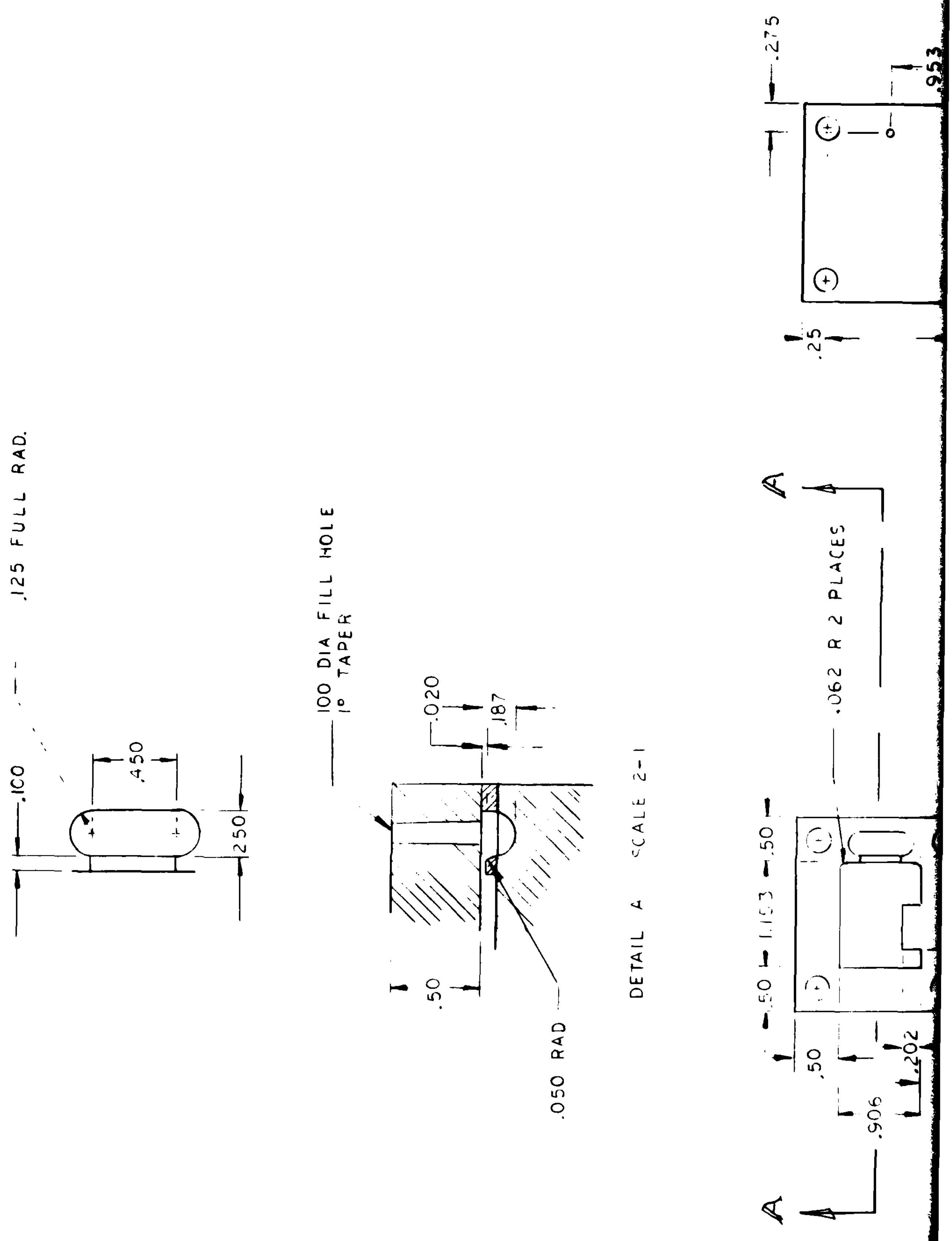
SECTION C-C

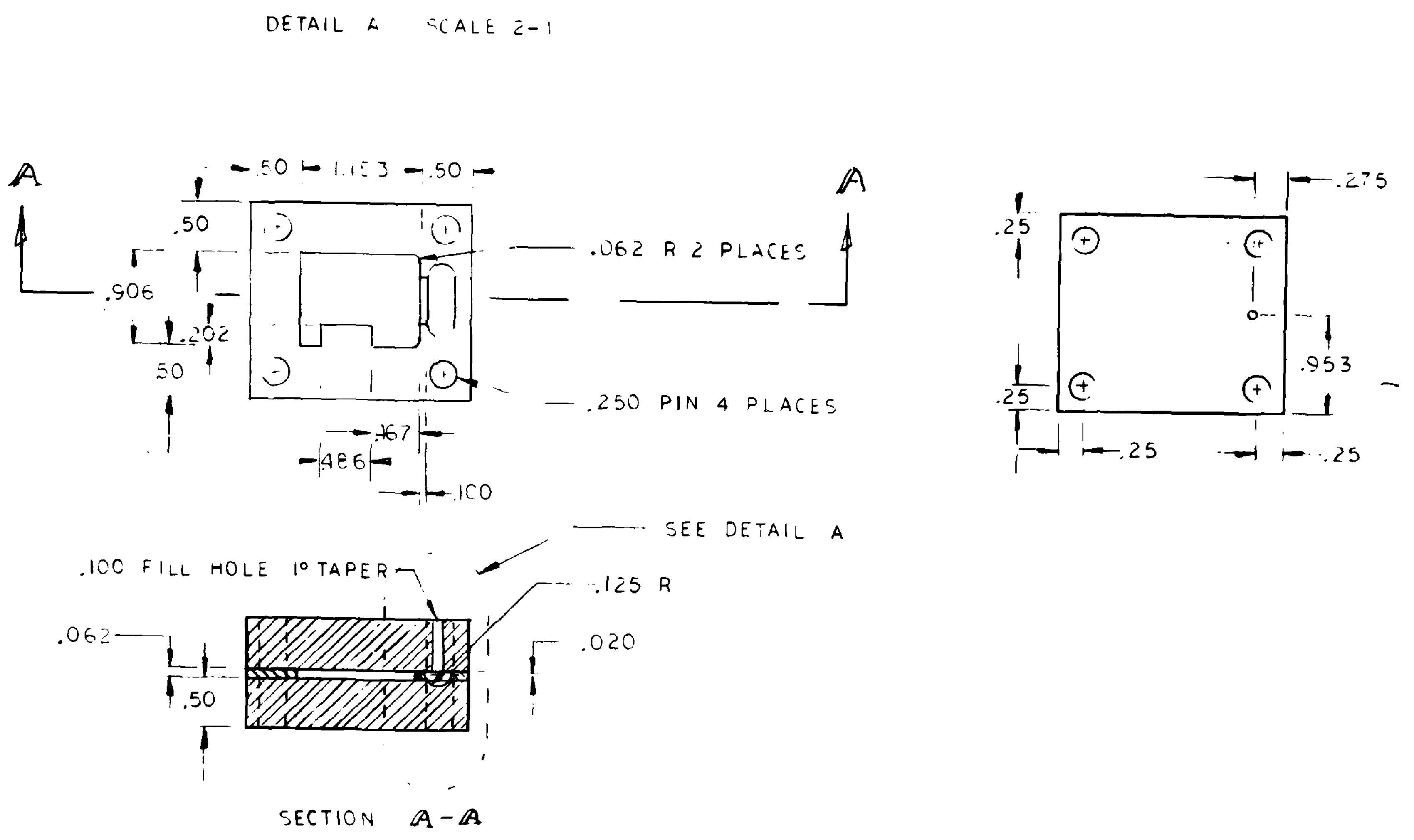
CAVITY FINISH — POLISH 6?3

DIMENSION TOLERANCES
.XXXX ± .0002
.XXX ± .005
.XX ± .010

CAVITY MOLD
CAP 513 FILTER

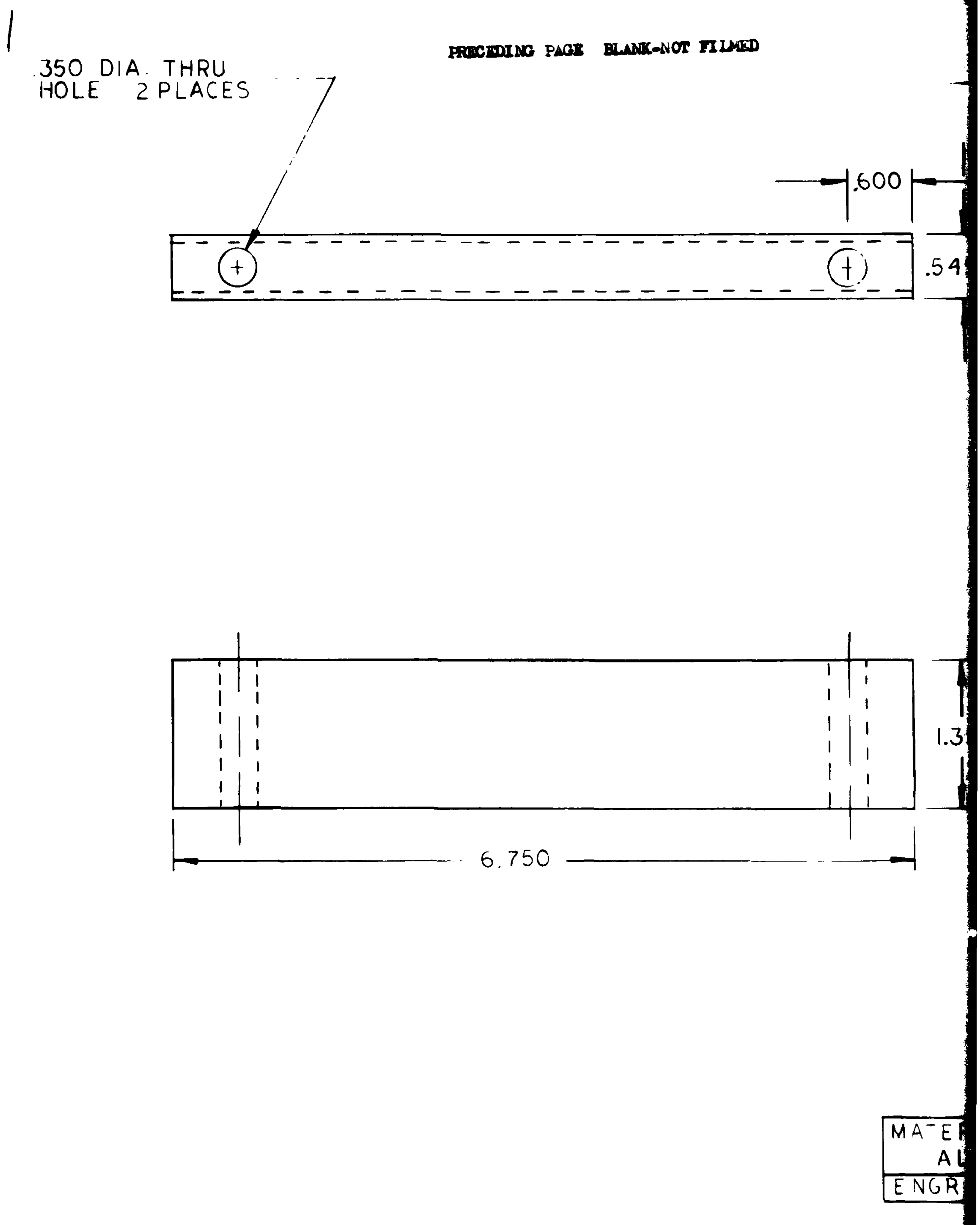
ENGR. N. L. ... 9/79 DRAWN SIMS
MATERIAL
440C STAINLESS STEEL, 52-54 Rc
REVISION A
.4-6-100
SCALE 3/1
SHEET 2 OF 2


.125 FULL RAD.
.100
.450
.250
.100 DIA FILL HOLE
1° TAPER
.020
.187
.50
.050 RAD
DETAIL A SCALE 2-1
.062 R 2 PLACES
.275
.953
.25
.50
1.153
.50
.50
.906
.202
A
A

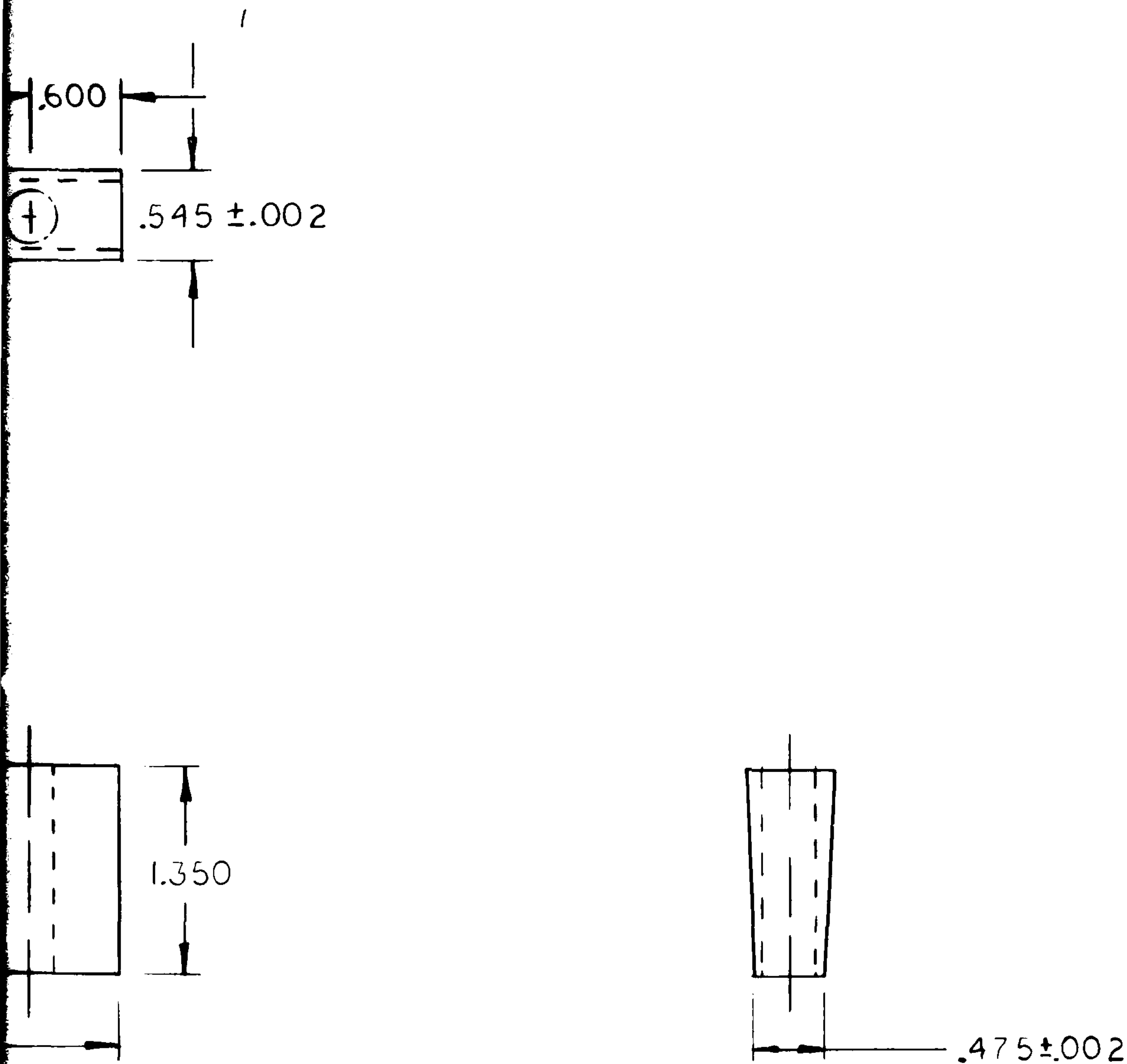


DIMENSIONS .XX ± .010 .XXX ±.002	CAVITY MOLD		
	S-13 FILTER END CAP		
MATERIAL MILD STEEL	24-6-106		
ENGR [signature] 2/21/80	DWN RES	SCALE 1-1	SHEET 1 OF 1

PRECEDING PAGE BLANK-NOT FILMED

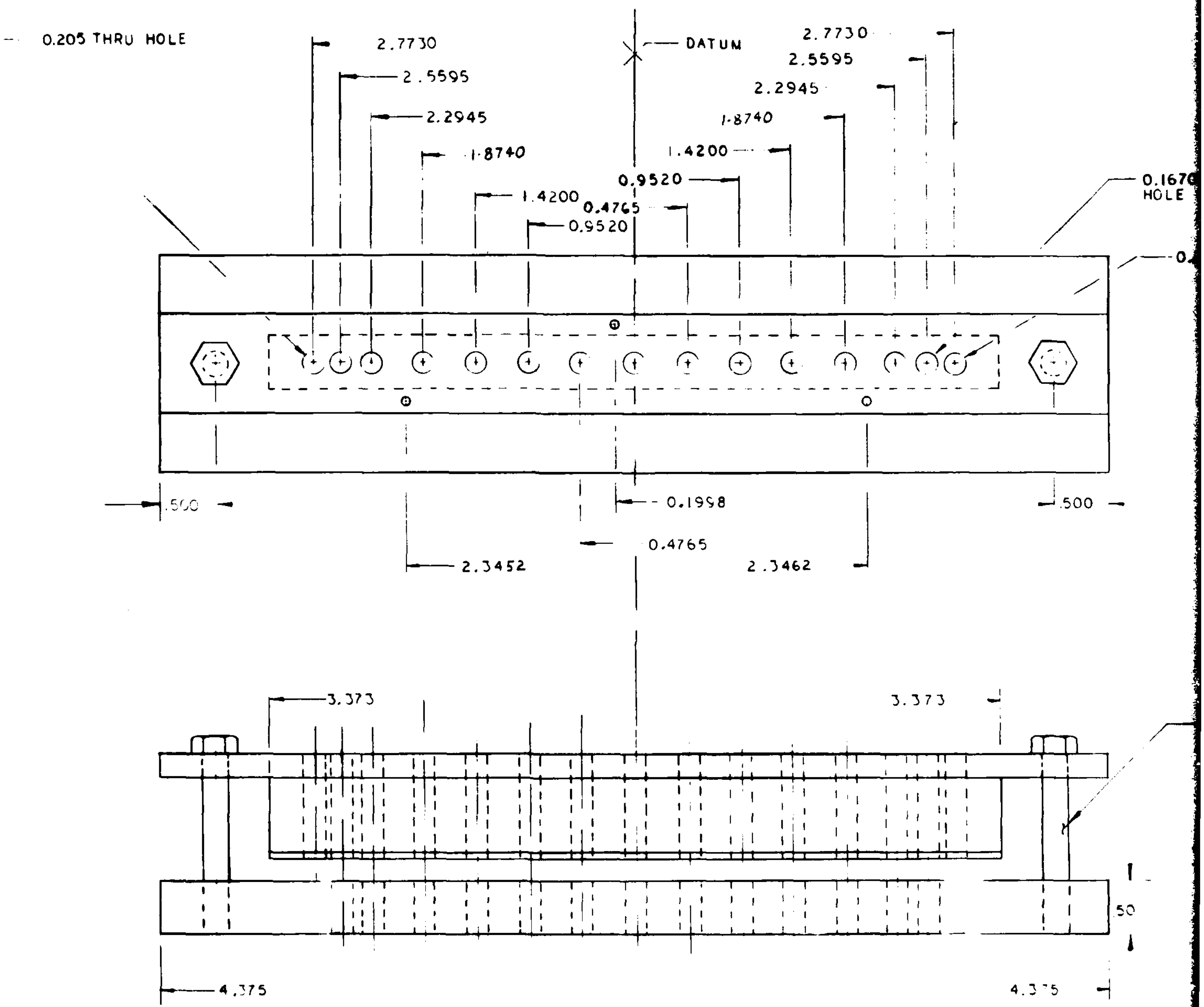


2

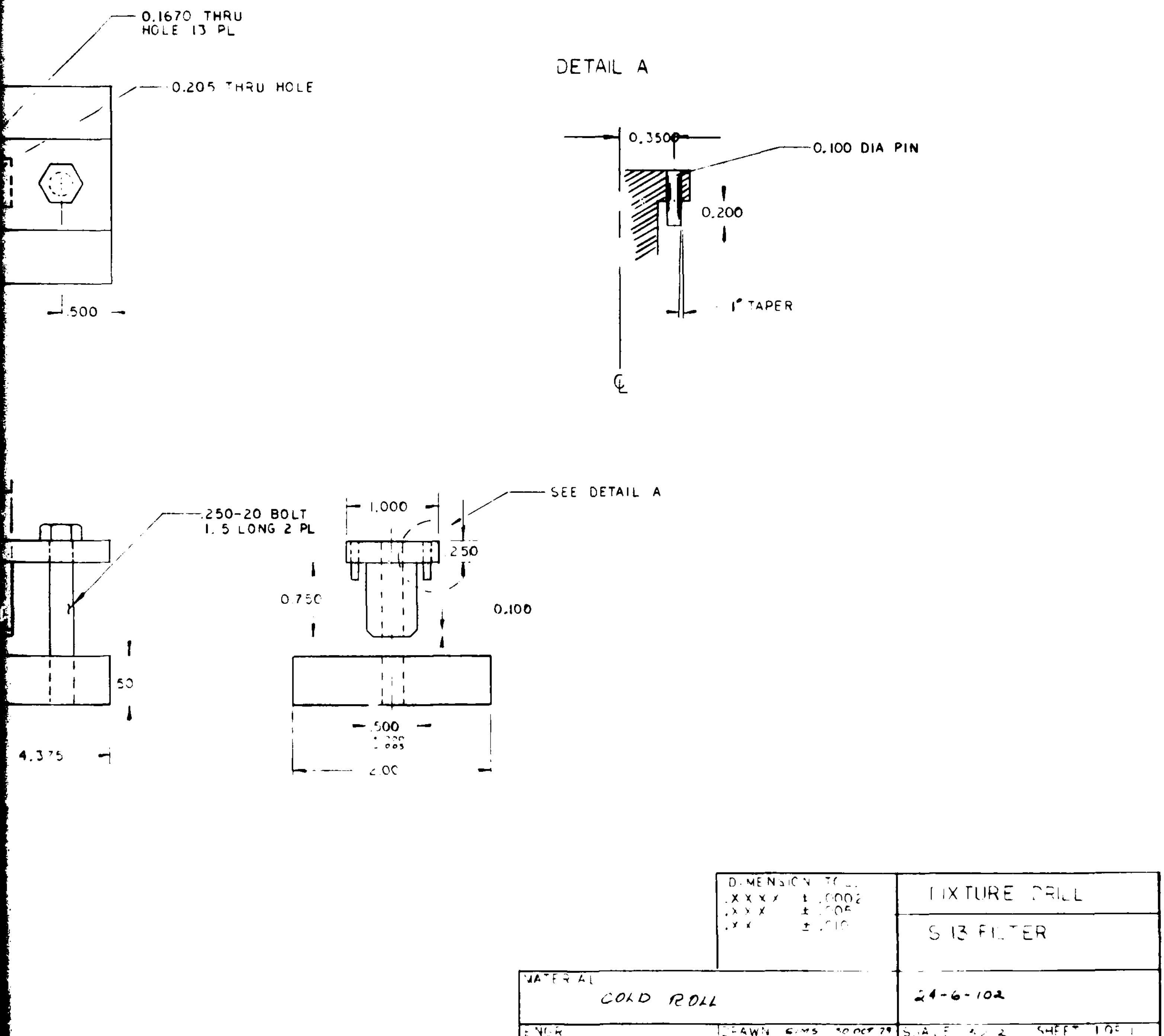


	BODY ANNEALING FIXTURE
	S 13 FILTER
MATERIAL ALUM 6061 T6	24-6-103
ENGR [illegible] 2/21/80	DWN RES | SCALE 1-1 | SHEET 1 OF 1

PRECEDING PAGE BLANK-NOT FILMED

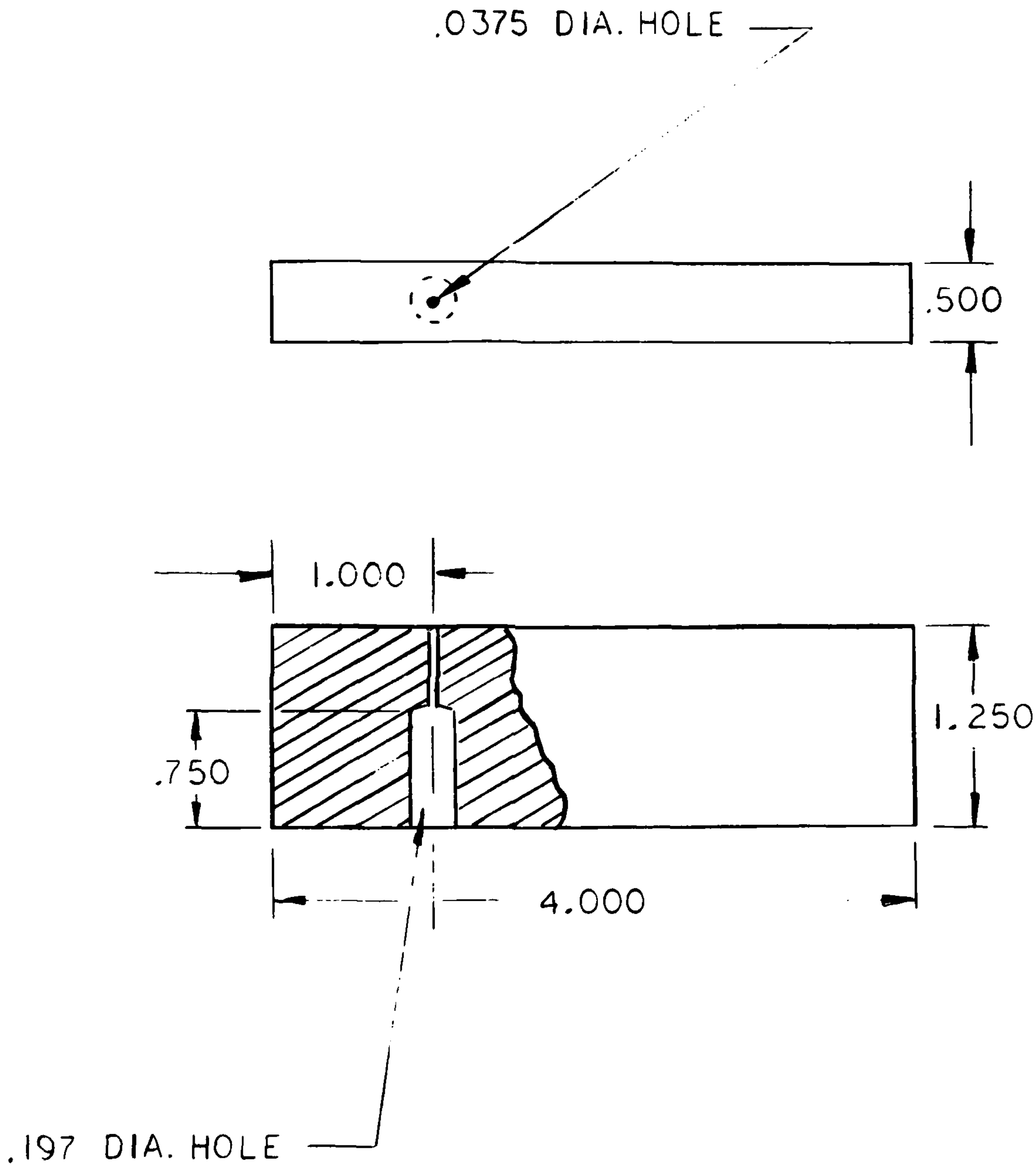


2



0.1670 THRU HOLE 13 PL
0.205 THRU HOLE
.500
DETAIL A
0.3500
0.100 DIA PIN
0.200
1° TAPER
℄
SEE DETAIL A
.250-20 BOLT 1.5 LONG 2 PL
1.000
.250
0.750
0.100
.50
.500
2.00
4.375
DIMENSION TOL
.XXXX ± .0002
.XXX ± .005
.XX ± .010
FIXTURE DRILL
S 13 FILTER
MATERIAL
COLD ROLL
24-6-102
ENGR
DRAWN
SCALE
SHEET 1 OF 1

PRECEDING PAGE BLANK-NOT FILMED



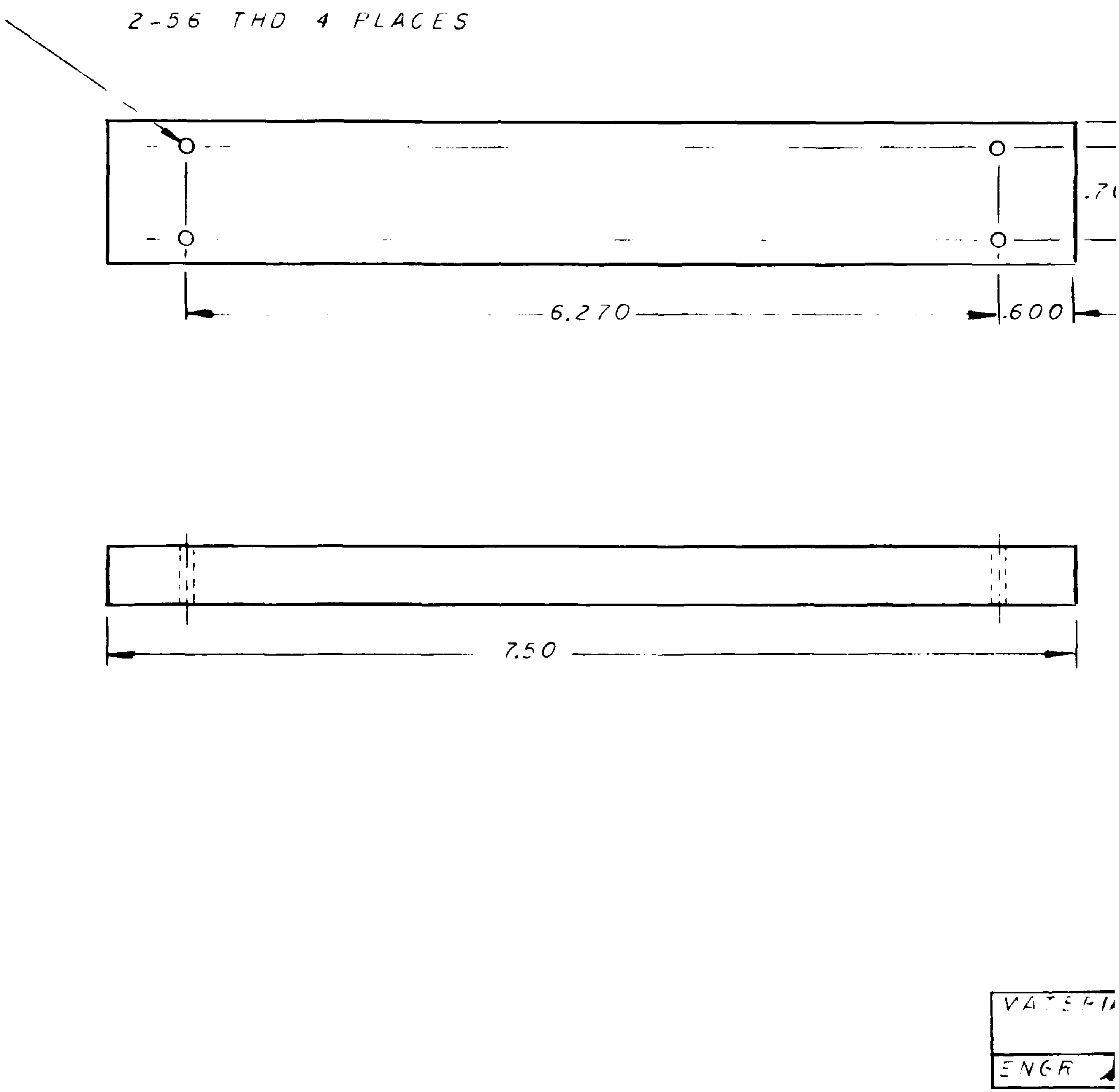
MATERIAL MILD STEEL	
ENGR	3/5/80

2

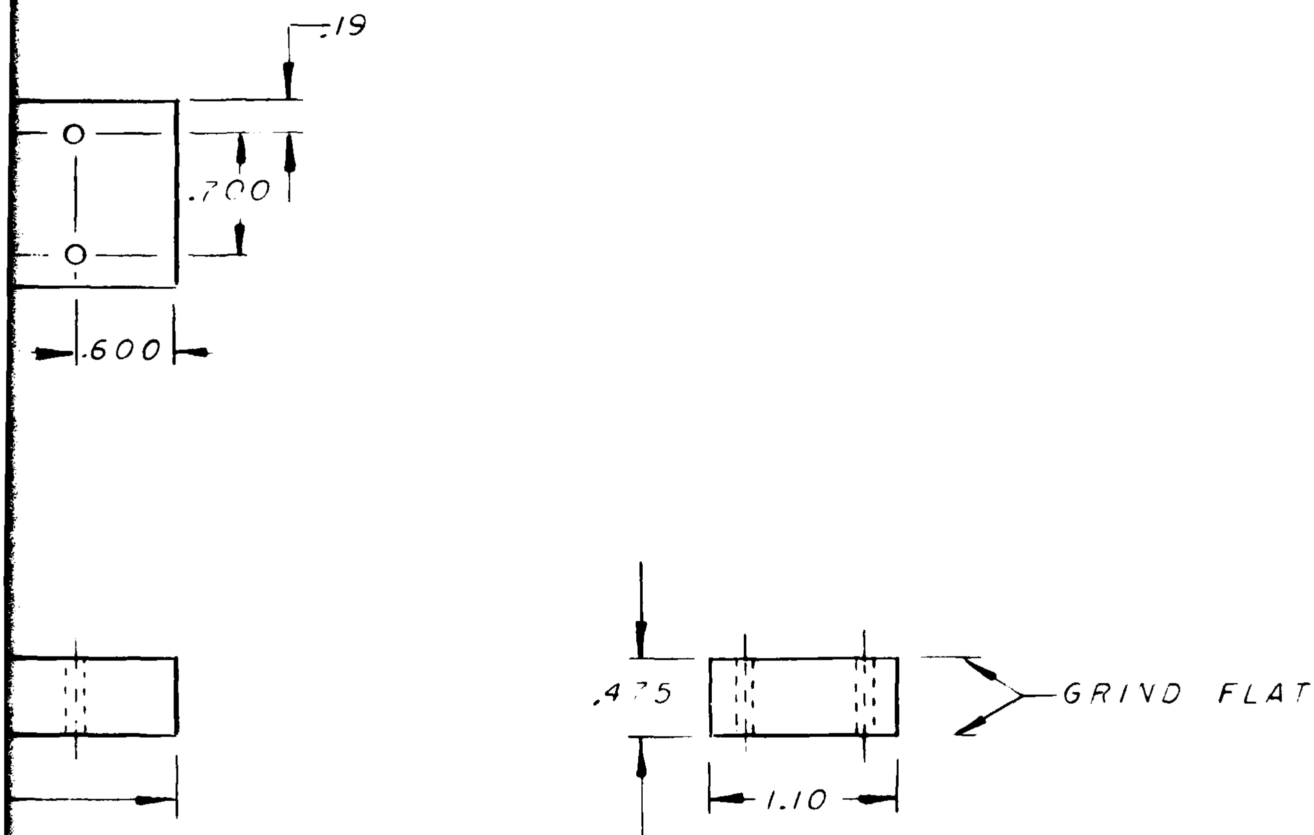
50

	DRILL FIXTURE INPUT/OUTPUT POSTS		
	S-13 FILTER		
MILD STEEL	24-6-105		
Pardy 3/5/85	DWN RES	SCALE 1-1	SHEET 1 OF 1

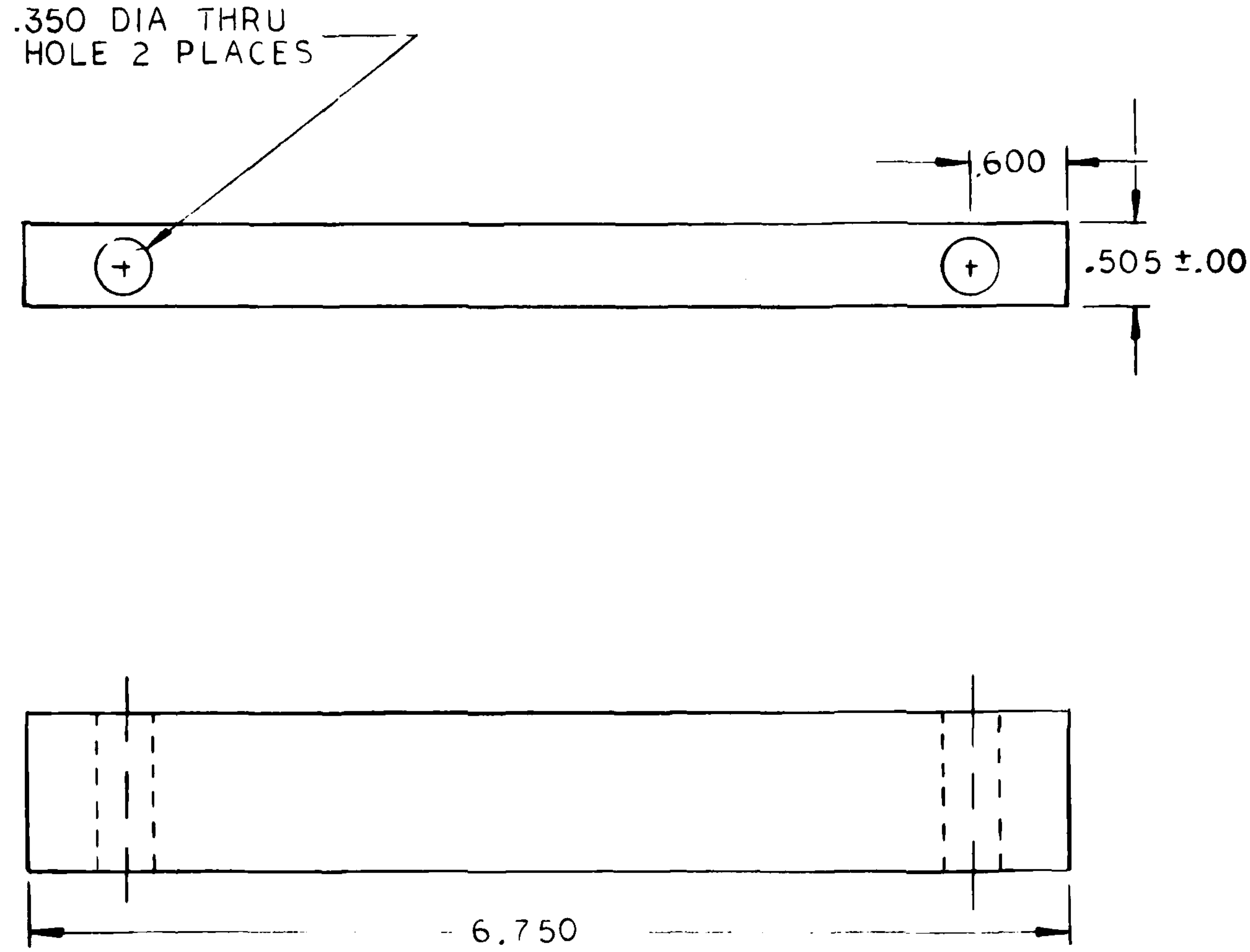
PRECEDING PAGE BLANK-NOT FILMED



2

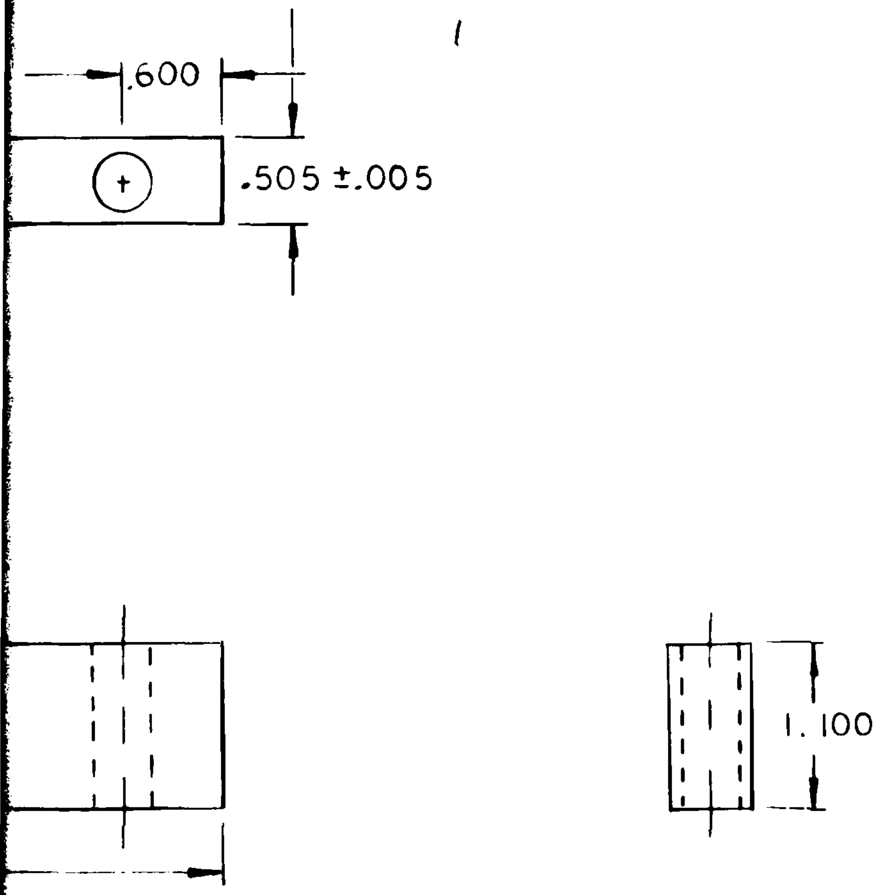


	FIXTURE		
	S-13 FILTER		
MATERIAL ALUM 6061 T6	24-5-107		
ENGR [signature] 3/5/60	DWN RES	SCALE 1-1	SHEET 1 OF 1



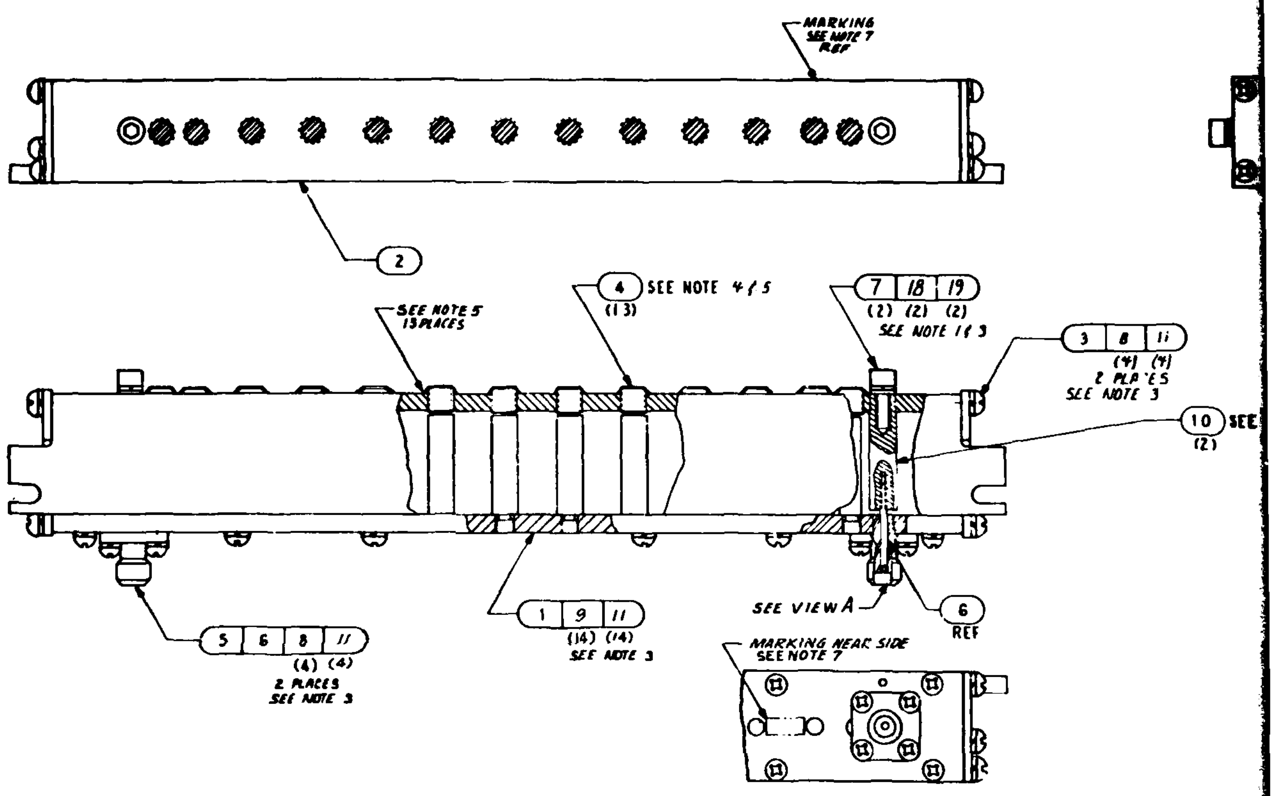
MATERIAL ALUM 6061 T6	
ENGR	3/5/80

2



	BODY ANNEALING FIXTURE
	S 13 FILTER
IAL ALUM 6061 T6	24-6-104
3/5/80	DWN RES | SCALE 1-1 | SHEET 1 OF 1

PRECEDING PAGE BLANK-NOT FILMED



NOTES

1. PRIOR TO SOLDERING CENTER CONDUCTOR (FIND NO 6). MATE PIECE PARTS TOGETHER (COVER AND CONNECTORS. END PINS AND HOUSING). THEN ADJUST CENTER CONDUCTOR TO YIELD THE FOLLOWING DIMENSIONS. SEE VIEW "A".
    1.1 DIELECTRIC INSULATOR GAP MEASURE FROM CONNECTOR BODY REF PLANE NOMINAL 0.000 (FLUSH) TO +.002 -.004 CENTER CONTACT GAP MEASURING FROM CONNECTOR BODY REF PLANE .000 (FLUSH) TO -.010. NOTE -.003 WITH RESPECT TO REFERENCE PLANE IS NOMINAL AFTER CENTER CONDUCTOR ADJUSTMENT RE-MATE COVER AND CONNECTOR LEAVING CENTER CONDUCTOR MATED TO HOUSING PIN. SOLDER FIND NO 6 CENTER CONDUCTOR IN PLACE TO PIN(FIND NO 10) INSTALL COVER TO HOUSING. THEN MATE CONNECTOR BODY(WITH DIELECTRIC) TO THE COVER OVER THE PROTRUDING CENTER CONDUCTOR
2. SOLDER IAW MIL-STD-454 REQUIREMENT 5. EXCEPT THAT TYPE RA FLUX IAW QQ-S-571 MAY BE USED USE FIND NO 16
3. PRIOR TO TUNING FILTER TORQUE FIND NO. 8 & 9 TO 25-30 IN OZ AND FIND NO 7 TO 4 5±2 IN LBS PAINT TO SIGNIFY COMPLETION OF TORQUE OPERATION IS NOT PERMISSIBLE
4. AFTER ASSEMBLY AND PRIOR TO APPLICATION OF FINAL PROTECTIVE COATING ELECTRICALLY TUNE UNITS, SEE NOTE 9, USING INDIVIDUAL TUNING SCREWS (FIND NO 4) FOR ADJUSTMENT
5. AFTER TUNING OPERATION IS COMPLETE LOCK FIND NO 4, TUNING SLUGS, IN PLACE USING A BEAD OF ADHESIVE (FIND NO 12). APPLIED EVENLY AROUND PERIPHERY
6. FINAL EXTERIOR FINISH (AFTER TUNING) EXCEPT FOR CONNECTORS (THREADS AND INTERFACE) AND TUNING SLUGS SHALL BE AS FOLLOWS
    6.1 SPRAY COAT WITH FIND NO 13 FOLLOWED BY FIND NO 15 .0005 TO .0008 THICK
    6.2 FINAL FINISH SPRAY WITH FIND NO 17 .0015 TO .0025 THICK
    6.3 THICKNESS TO BE CONTROLLED THRU PROCESS SURVEILLANCE

NOTES (CONT)

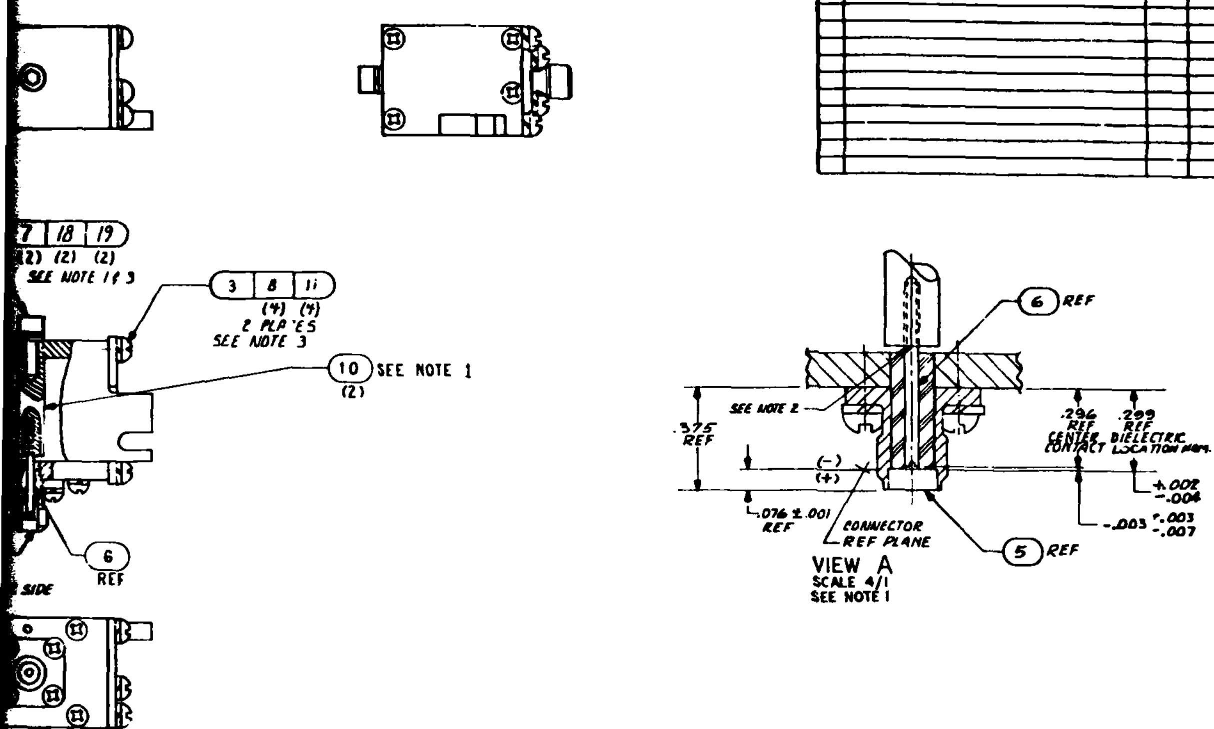
7. ASSEMBLY (FIND NO 1) AND HOUSING (FIND NO 2) ARE MATCHED SETS SERIAL NO S OF EACH PART SHOULD MATCH NOTE NON-MATCHING SERIAL NO S PRIOR TO START OF ASSY IS CAUSE FOR REJECTION
    7.1 RECORD SERIAL NO S OF SUB-INDENTURE PARTS (BRAZED ASSY AND HOUSING) PRIOR TO FINAL FINISH
    7.2 IDENTIFY WITH CODE IDENT PART NO REVISION LETTER AND SERIAL NO IAW MIL-STD-130 LOCATE APPROXIMATELY AS SHOWN
8. CAUTION UNITS MUST BE KEPT FREE AND CLEAR OF ANY FOREIGN MATERIAL DURING ASSEMBLY ANY FOREIGN MATERIAL WITHIN ASSEMBLED UNIT WILL PREVENT SATISFACTORY TUNING
9. FOR TEST PARAMETERS SEE DRAWING 5186581

2

PL	REV STATUS OF SHEETS					
-	5	4	3	2	1	SHEET NO
A					A	REV LTR

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
	REIDENTIFIED-DRAWING NO WAS 3244200B		
	NAVSEA CHANGE CONTROL		
A	SEE ECP PN1300-6 (CO 321306)		



VIEW A
SCALE 4/1
SEE NOTE 1

...AND HOUSING (FIND NO 2) ARE MATCHED SETS
...SHOULD MATCH NOTE NON-MATCHING SERIAL
...IS CAUSE FOR REJECTION
...SUB-IDENTURE PARTS (BRAZED ASSY AND HOUSING)

...T. PART NO REVISION LETTER AND SERIAL NO
...CATE APPROXIMATELY AS SHOWN
...PT FREE AND CLEAR OF ANY FOREIGN MATERIAL
...IGN MATERIAL WITHIN ASSEMBLED UNIT WILL
...

...DRAWING 5186581

SEE SEPARATE PARTS LIST

INTERPRET DRAWING IN ACCORDANCE WITH THE GENERAL REQUIREMENTS OF MIL-STD-100B

5187854	CIWS
NEXT ASSEMBLY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON .XXX = ± .010 ANGLES ± 2° .XX = ± .03 FRACTIONS ±

MATERIAL

CONTR NO N00024-76-C-7171

GENERAL DYNAMICS
Pomona Division 99684
POMONA, CALIFORNIA

ENGR / PROD / CHK / PREP / GOVT APPROVAL

NAVSEA CHANGE CONTROL
DATE

MFG ENGR

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON D C 20362

FILTER ASSEMBLY, S-13

SIZE	CODE IDENT NO	DRAWING NUMBER
D	53711	5188423

SCALE 2/1 UNIT WT NA SHEET 1 OF 1

PBT

5188423

PRECEDING PAGE BLANK-NOT FILMED

NOTES.

1. PRESS FIND NO 2 THRU 8 INTO FIND NO. 1 FROM SIDE INDICATED SEE REFERENCE DIMENSIONS TO .0629 DIA HOLES FOR PROPER PIN ORIENTATION PIN SHOULDER MUST BOTTOM AGAINST FIND NO. 1 COVER FOR PROPER PIN INSTALLATION

2. AFTER PRESS FIT BRAZE COVER-PIN ASSY IAW MIL-B-7883B. TYPE V. GRADE A EXCEPT RADIOGRAPHIC EXAMINATION IAW PAR 4.4.2 IS NOT REQUIRED BRAZING FILLET MAY NOT EXCEED .015 R AT MATING SURFACE BETWEEN PINS AND COVER.

3. AFTER BRAZING. PINS MUST BE PERPENDICULAR TO SURFACE -A- WITHIN .003.

4.

5. SURFACE TREATMENT

5.1 COPPER PLATE IAW MIL-C-14550. CLASS 4. .00015 MAX THICK.

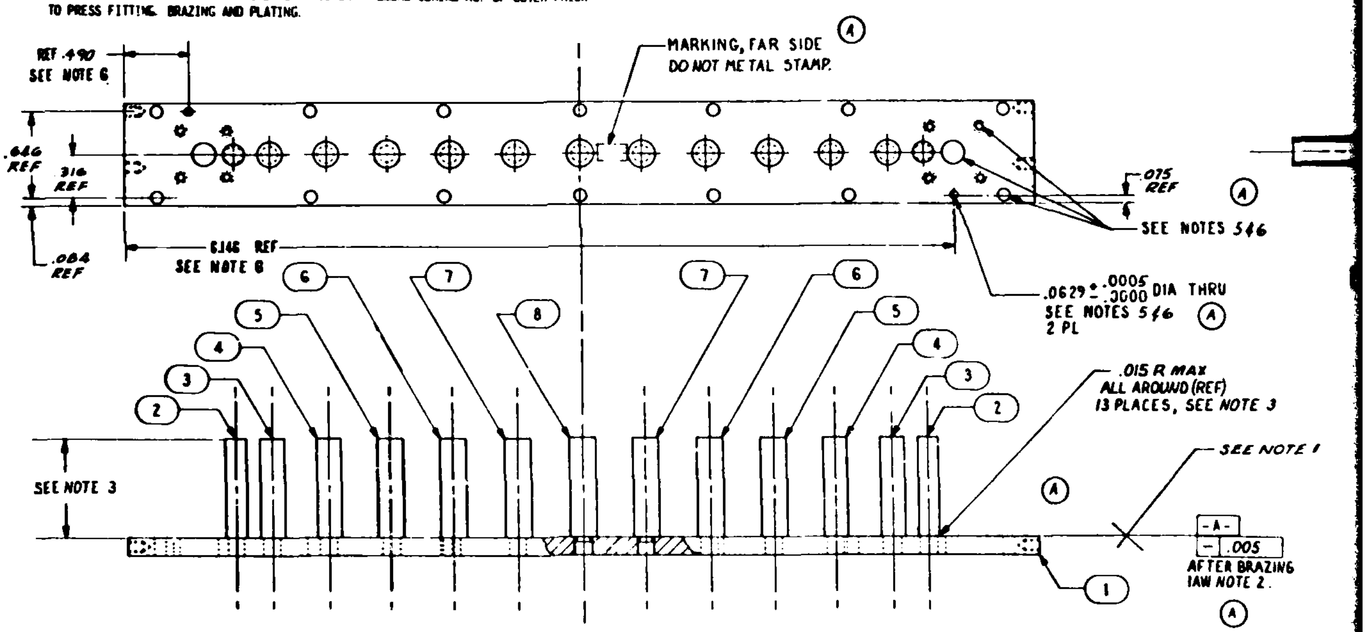
5.2 AFTER COPPER PLATING. GOLD PLATE IAW MIL-G-45204. TYPE I GRADE A .00005 MIN THICKNESS. FOLLOWED BY GOLD PLATE IAW MIL-G-45204. TYPE I. GRADE C. CLASS 2. PLATING IN THREADED AND THROUGH HOLES OPTIONAL EXCEPT AS NOTED CAUTION NO PLATING PERMITTED IN .0629 DIA HOLES

6. AFTER PLATING TOUCH-UP ALL UNPLATED, THREADED AND THRU HOLES WITH CHEMICAL FILM TREATMENT IAW MIL-C-5541. CLASS 3. (ELECTRICALLY CONDUCTIVE).

7. IDENTIFY WITH CODE IDENT. PART NO., REVISION LETTER AND SERIAL NO IAW MIL-STD-130 LOCATE APPROXIMATELY AS SHOWN SERIAL NO. OF THIS ASSEMBLY WILL BE IDENTICAL TO THE SERIAL NO REGISTERED ON FIND NO 1 COVER RECORD SERIAL NO. OF COVER PRIOR TO PRESS FITTING. BRAZING AND PLATING.

NOTES: (CONTD)

8. THIS COVER IS A MATCHED SET WITH 5188425-1 HOUSING IT SHALL BE IDENTIFIED WITH SAME SERIAL NO AS ITS MATING BODY AND THE PARTS SHALL BE STOCKED AND KITTED AS A MATCHED SET.

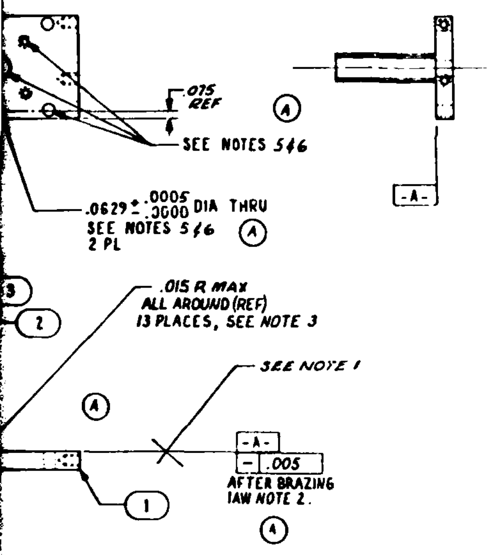


2

...S-1 HOUSING. IT SHALL
...ITS MATING BODY AND THE
...MATCHED SET.

PL	REV STATUS OF SHEETS					
–	5	4	3	2	1	SHEET NO
A					B	REV LTR

LTR	REVISIONS DESCRIPTION	DATE	APPROVED
	REIDENTIFIED DRAWING NO. WAS 3244ZC1A		
	NAVSEA CHANGE CONTROL	6-13-77	
A	SEE ECP PH1300-8 (CO 321392)		
B	SEE ECP PH1300-10 (CO 321442)		



SEE SEPARATE PARTS LIST

INTERPRET DRAWING IN ACCORDANCE WITH THE GENERAL REQUIREMENTS OF MIL-STD-100B

CONTR NO	N00024-76-C-7171
	GENERAL DYNAMICS Pomona Division, POMONA, CALIFORNIA
	DEPARTMENT OF THE NAVY, NAVAL SEA SYSTEMS COMMAND, WASHINGTON D.C. 20362
NEXT ASSEMBLY	5188423
USED ON	CIWS
APPLICATION	
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ON:	.XXX = ± .010; .XX = ± .03; ANGLES ± 2°; FRACTIONS ±
MATERIAL	
ENGR	6/10/77
PROD	
CHK	
PREP	
NAVSEA CHANGE CONTROL DATE	6-13-77
MFG ENGRG	6-10-77
TITLE	COVER ASSEMBLY, S-13 FILTER (A)
SIZE	D
CODE IDENT NO	53711
DRAWING NUMBER	5188424
SCALE	2/1
UNIT WT	NA
SHEET	1 OF 1

PBT

5188424

PRECEDING PAGE BLANK-NOT FILMED

NOTES

1. FIND NO 4 DOWEL PINS IN -4 BODY ARE ASSEMBLY LOCATING DEVICES AND ARE PERMISSIBLE TOOLING AIDS FOR DRILLING AND MACHINING THE .0629 DIA DOWEL PIN HOLES AND .173 DIA HOLES IN -2 COVER MUST BE MATCH OR "IN-LINE" DRILLED TO MATE WITH THE .0616 AND .1560 DIA HOLES IN -4 BODY, RESPECTIVELY. NOTED TAPPED AND THRU HOLES ARE IDENTIFIED BY SYMBOL ⊕

2. IT IS PERMISSIBLE TO MATE -4 BODY AND -2 COVER TOGETHER TO MATCH DRILL THE .086-56 UNC-2B THD IN -4 BODY AND .0960 DIA HOLES IN -2 COVER. NOTED TAPPED AND THRU HOLES ARE IDENTIFIED BY THE SYMBOL ⊕

3. WITH DATUM -B OF -4 BODY AND DATUM -D OF -2 COVER MATED AND WHILE HOLDING DATUM -A- OF -4 BODY AND DATUM -C- OF -2 COVER COINCIDENT WITHIN .000 TO .010 GAP (SEE VIEW A). MACHINE THE OPPOSITE (OPEN) ENDS OF -4 BODY AND -2 COVER TOGETHER ANYWHERE WITHIN THE ±.005 COMMON TOLERANCE ZONE TO MEET THE OVERALL LENGTH OF 6.746 AND GAP AS SHOWN IN VIEW A

4. PRESS FIND NO 4 DOWEL PINS INTO .0616 DIA HOLES IN -4 BODY TO DIMENSION SHOWN USING FIND NO 5 PRIMER AS A LUBRICANT. NO SURFACE TREATMENT IAW NOTES 5.1 AND 5.2 IS PERMITTED ON EXPOSED SECTION OF FIND NO 4 DOWEL PINS. THIS OPERATION CREATES -1.

5. SURFACE TREATMENT (-1 AND -3 ONLY)

5.1 COPPER PLATE IAW MIL-C-14550 CLASS 4.

5.2 AFTER COPPER PLATING GOLD PLATE IAW MIL-G-45204 TYPE I GRADE A .00005 MIN THICKNESS FOLLOWED BY GOLD PLATE IAW MIL-G-45204 TYPE I GRADE C CLASS 2 NOTE PLATING IN THREADED AND THROUGH HOLES OPTIONAL. CAUTION FOR -1 ONLY PLATING OF FIND NO 4 DOWEL PINS IS PROHIBITED

5.3 AFTER PLATING, TOUCH UP ALL UNPLATED THREADED AND THRU HOLES WITH CHEMICAL FILM TREATMENT IAW MIL-C-5541 CLASS 3 (ELECTRICALLY CONDUCTIVE).

6. SURFACE TREATMENT (-2 ONLY) NONE. -2 COVER WILL BE TREATED AT NEXT ASSEMBLY.

7.

8. *IDENTIFY PARTS WITH CODE IDENT, PART NO, DASH NO, REVISION LETTER AND (FOR -1 AND -3)* VIBROETCH SERIAL NO ON -1 HOUSING ASSY AND -2 COVER WITH .062 TO .093 HIGH GOTHIC STYLE LETTERS. SERIAL NO TO BE LEGIBLE AFTER PLATING IAW NOTE 5. DO NOT METAL STAMP

9. DIMENSIONAL LIMITS APPLY AFTER PLATING.

10. BEFORE SURFACE TREATMENT, REMOVE BURRS AND BREAK SHARP EDGES .010 MAX

11. TRUE POSITION OF ALL THREADED HOLES SHALL BE TO MINOR DIAMETER

12. ALL SINGLE ARROW DIMENSIONS ARE TAKEN FROM DATUM.

13. ALL FILLET RADII TO BE .015 MAX, UNLESS OTHERWISE SPECIFIED

14. .1560 DIA HOLE SHALL BE TO SIZE AFTER PLATING AND MAY BE FINISHED AFTER PLATING IAW NOTE 5.

TABLE 1		
DASH NO.	NEXT ASSY NO	FIND NO. USED
-2	5188424	2 ONLY
-1	5188423	1, 4 & 5
-3	5188423	3 ONLY

2

PL	REV STATUS OF SHEETS					
-	5	4	3	2	1	SHEET NO
-			B	B	B	REV LTR

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
	RE-IDENTIFIED DRAWING NO. WAS 3244202A		
	NAVSEA CHANGE CONTROL	6-13-77	
A	SEE ECP PH1300-7 (CC 320/28)		
B	SEE ECP PH1300-8 (CC 321353)	3-3-	

SEE SEPARATE PARTS LIST

INTERPRET DRAWING IN ACCORDANCE WITH THE GENERAL REQUIREMENTS OF MIL-STD-100B

FIND NO. USED
2 ONLY
1, 4 & 5
3 ONLY

NEXT ASSEMBLY	USED ON
SEE TABLE I	CIRS

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON DECIMALS ANGLES FRACTIONS

MATERIAL

CONTR NO N00024-76-C-7171

GENERAL DYNAMICS
Pomona Division 99584

ENGR 6/6/77
PREP 1-6-77

NAVSEA CHANGE CONTROL DATE 6-13-77

MFG ENGRG 6-5-77

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON D C 20362

HOUSING, S-13 FILTER

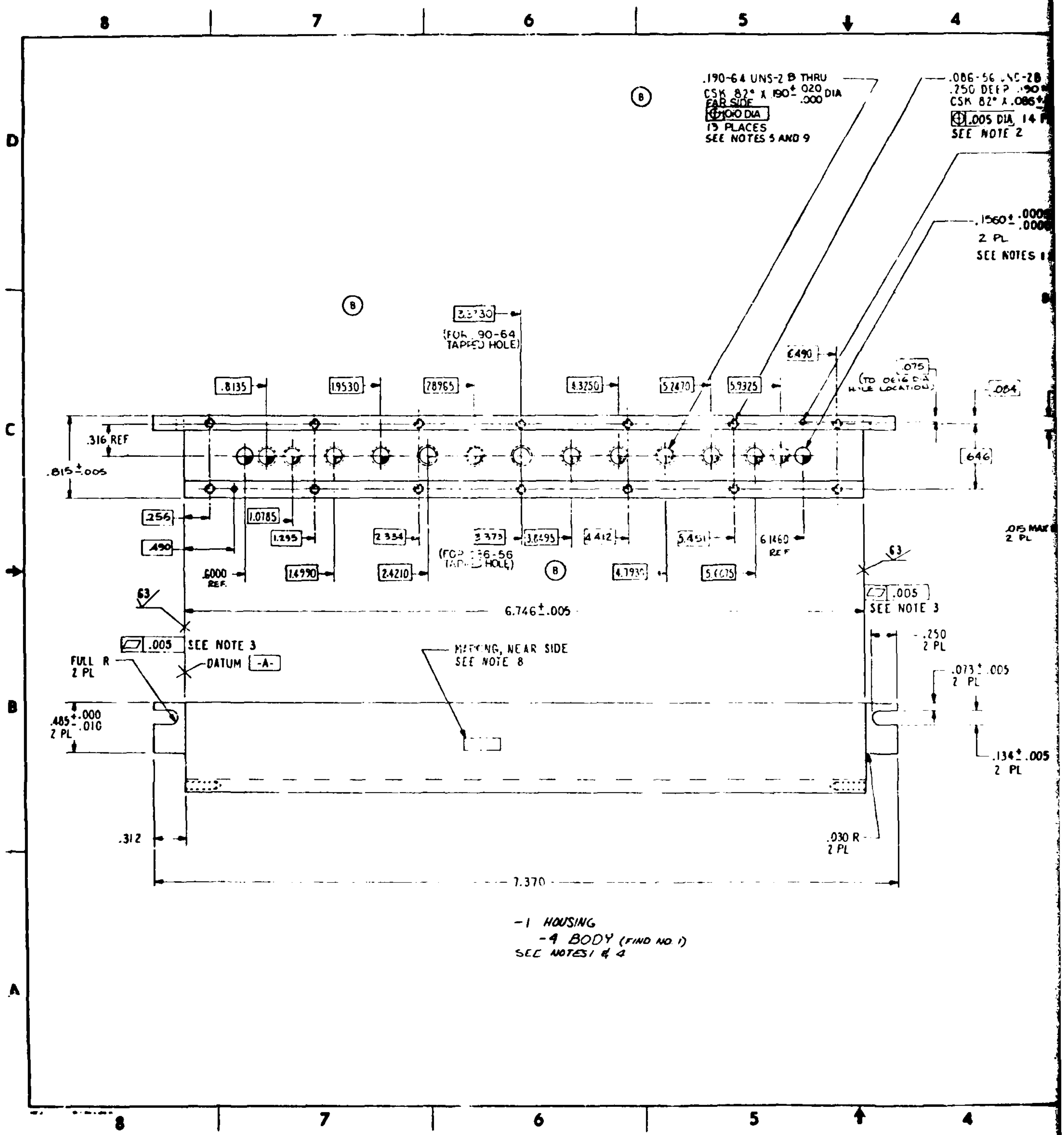
SIZE	CODE IDENT NO	DRAWING NUMBER
D	53711	5188425

SCALE NONE UNIT WT NA SHEET 1 OF 1

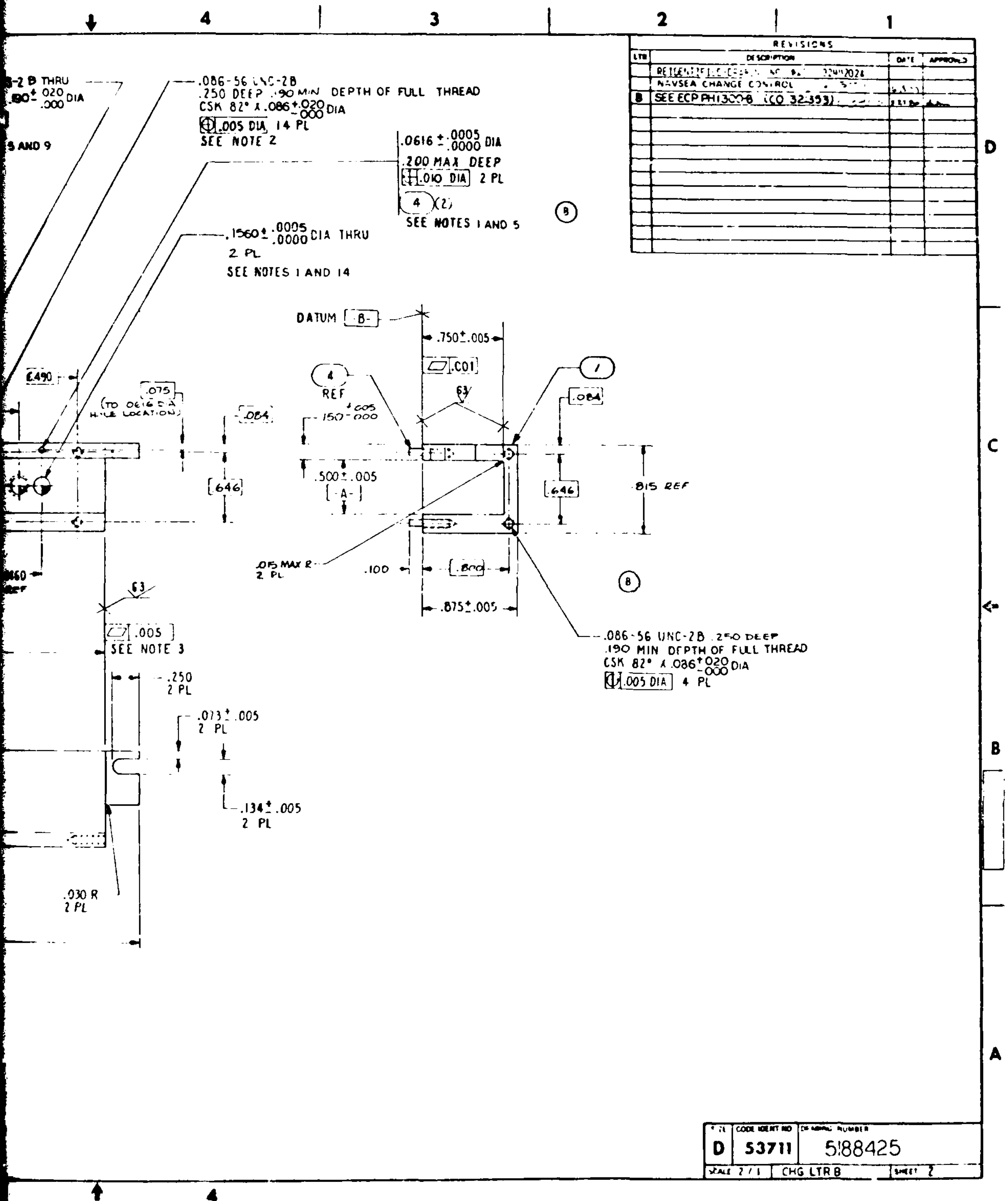
PBT

5188425

PRECEDING PAGE BLANK-NOT FILMED

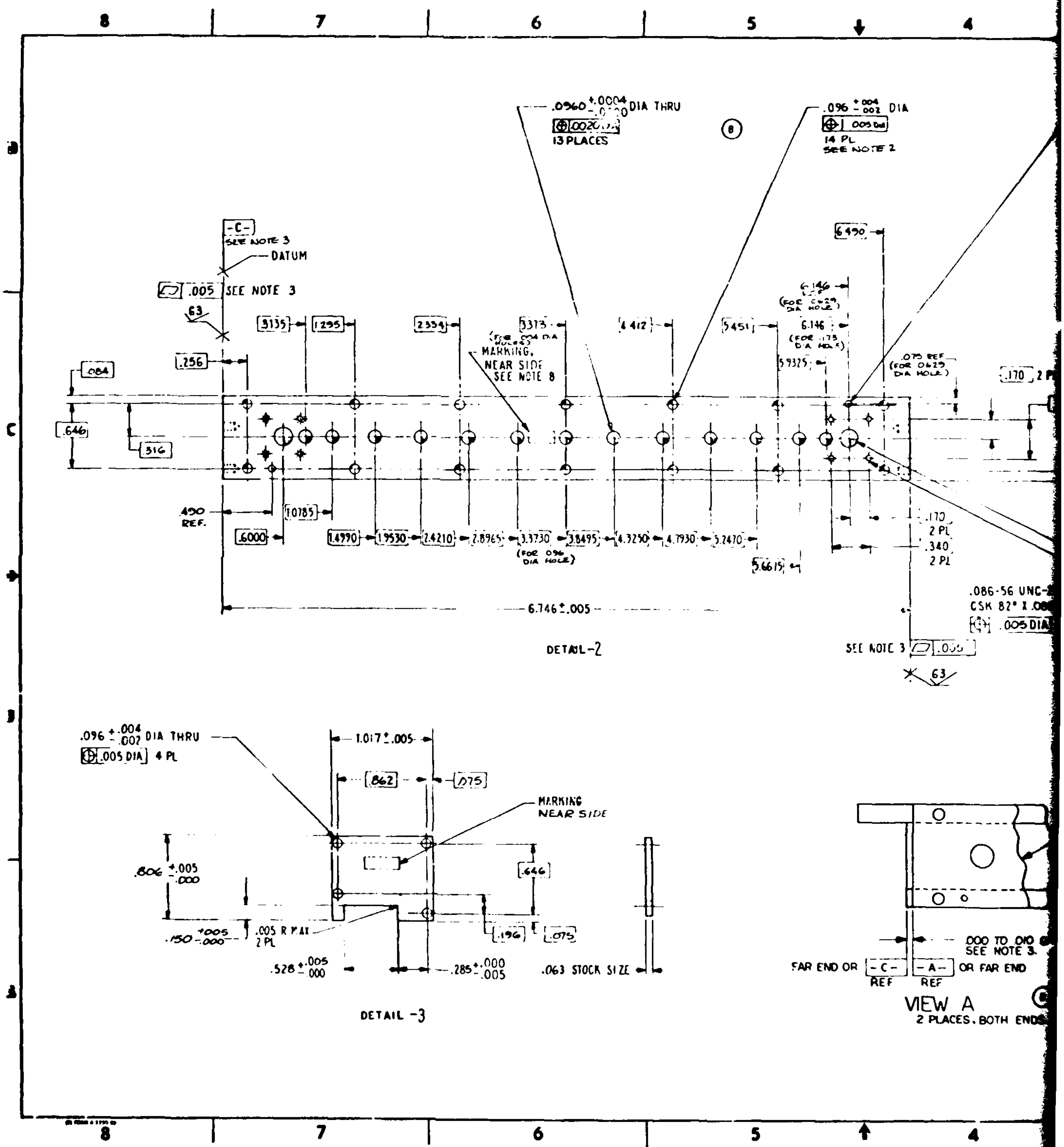


2

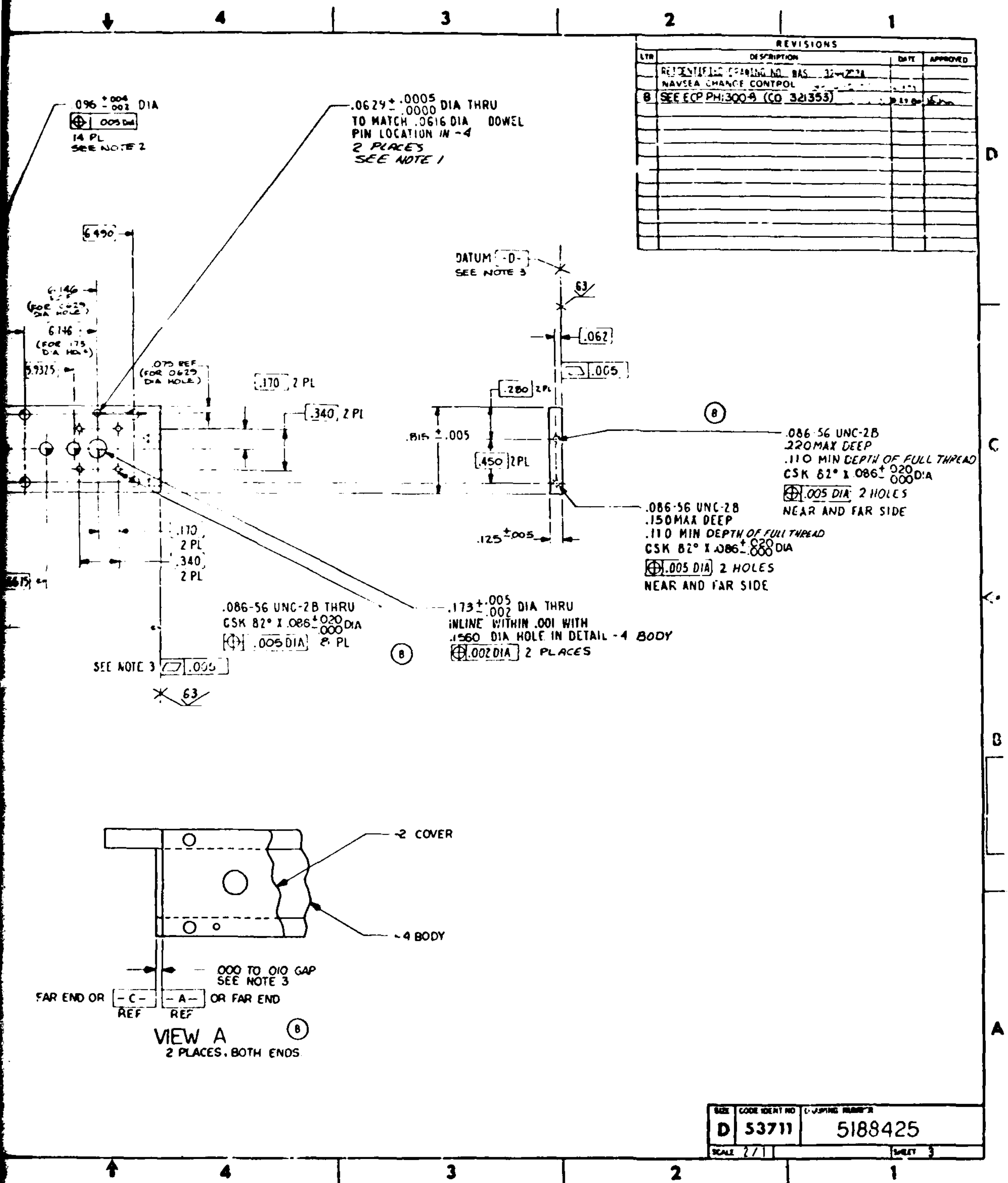


REVISIONS
LTR | DESCRIPTION | DATE | APPROVED
NAVSEA CHANGE CONTROL
B | SEE ECP PH1300-B (CO 32-353)
.086-56 UNC-2B
.250 DEEP .190 MIN DEPTH OF FULL THREAD
CSK 82° X .086 +.020 -.000 DIA
.005 DIA 14 PL
SEE NOTE 2
.0616 +.0005 -.0000 DIA
.200 MAX DEEP
.010 DIA 2 PL
SEE NOTES 1 AND 5
.1560 +.0005 -.0000 DIA THRU
2 PL
SEE NOTES 1 AND 14
S AND 9
DATUM -B-
.750±.005
.001
REF
.150 +.005 -.000
.500±.005
-A-
.646
.084
.815 REF
.015 MAX R
2 PL
.100
.800
.875±.005
.086-56 UNC-2B .250 DEEP
.190 MIN DEPTH OF FULL THREAD
CSK 82° X .086 +.020 -.000 DIA
.005 DIA 4 PL
.075
(TO .0616 DIA HOLE LOCATION)
.005
SEE NOTE 3
.250
2 PL
.073±.005
2 PL
.134±.005
2 PL
.030 R
2 PL
D
53711
5188425
SCALE 2/1
CHG LTR B
SHEET 2

PRECEDING PAGE BLANK-NOT FILMED



2



4
3
2
1
REVISIONS
LTR
DESCRIPTION
DATE
APPROVED
REIDENTIFIED DRAWING NO. WAS
NAVSEA CHANGE CONTROL
B SEE ECP PH:300-B (CO 321353)
D
C
B
A
.096 +.004 -.002 DIA
.005 DIA
14 PL
SEE NOTE 2
.0629 +.0005 -.0000 DIA THRU
TO MATCH .0616 DIA DOWEL
PIN LOCATION IN -4
2 PLACES
SEE NOTE 1
6.490
6.146 (FOR .0629 DIA HOLE)
6.146 (FOR .173 DIA HOLE)
5.9325
.075 REF (FOR .0629 DIA HOLE)
.170 2 PL
.340 2 PL
DATUM -D-
SEE NOTE 3
63
.062
.005
.280 2 PL
.815 ± .005
.450 2 PL
.125 ±.005
.086-56 UNC-2B
.220 MAX DEEP
.110 MIN DEPTH OF FULL THREAD
CSK 82° X .086 +.020 -.000 DIA
.005 DIA 2 HOLES
NEAR AND FAR SIDE
.086-56 UNC-2B
.150 MAX DEEP
.110 MIN DEPTH OF FULL THREAD
CSK 82° X .086 +.020 -.000 DIA
.005 DIA 2 HOLES
NEAR AND FAR SIDE
.170
2 PL
.340
2 PL
.086-56 UNC-2B THRU
CSK 82° X .086 +.020 -.000 DIA
.005 DIA 8 PL
B
.173 +.005 -.002 DIA THRU
INLINE WITHIN .001 WITH
.1560 DIA HOLE IN DETAIL -4 BODY
.002 DIA 2 PLACES
SEE NOTE 3 .005
63
-2 COVER
-4 BODY
.000 TO .010 GAP
SEE NOTE 3
FAR END OR -C- REF
-A- REF OR FAR END
VIEW A
B
2 PLACES, BOTH ENDS
SIZE D
CODE IDENT NO 53711
DRAWING NUMBER 5188425
SCALE 2/1
SHEET 3

REV STA

NOTES:

1. BEFORE SURFACE TREATMENT, REMOVE BURRS AND BREAK SHARP EDGES .010 MAX.
2. COPPER PLATE IAW MIL-C-14550, CLASS 4, FOLLOWED BY GOLD PLATE IAW MIL-G-45204, TYPE I, GRADE A, .000005 MIN THICKNESS, FOLLOWED BY GOLD PLATE IAW MIL-G-45204, TYPE I, GRADE C, CLASS 2.
(NOTE: PLATING IN TAPPED OR THREADED HOLES OPTIONAL).
3. ALL DIMENSIONS ARE AFTER PLATING.
4. SURFACE ROUGHNESS: 63/.
5. DO NOT APPLY PART NO. TO PART IDENTIFY WITH CODE IDENT, PART NO., DASH NO. AND REVISION LETTER, IAW MIL-STD-130.

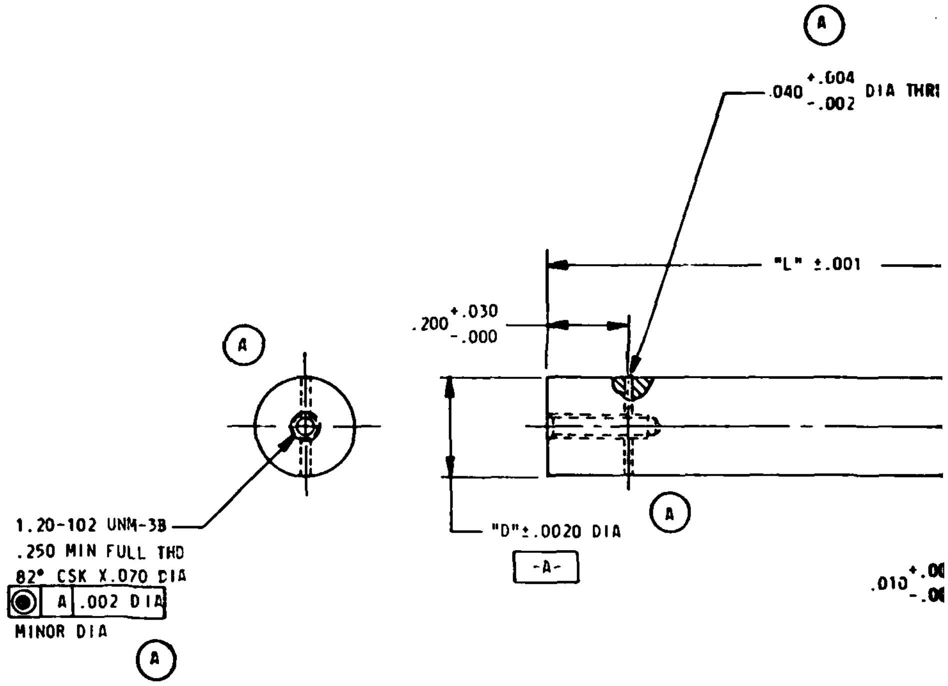


TABLE I		
DIAMETER & LENGTH CHART		
DASH NO.	"D" DIA	"L" LENGTH
-1	.2310	1.125
-2	.2000	.620
-3	.2350	1 270
-4	.1970	.720

INTERPRET DRAWING I

NEXT ASSEMBLY	USED ON
5188423 (B)	CIWS
5188426	CIWS
5188402 (A)	CIWS
5198160	CIWS
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
XXX = ± .010 ANGLES ± 2°
XX = ± .03 FRACTIONS ±

MATERIAL
BRASS ROD
ALLOY 360, 1/2 HARD
QQ-B-626

058-900-024
X "L" TABLE I

2 1

2

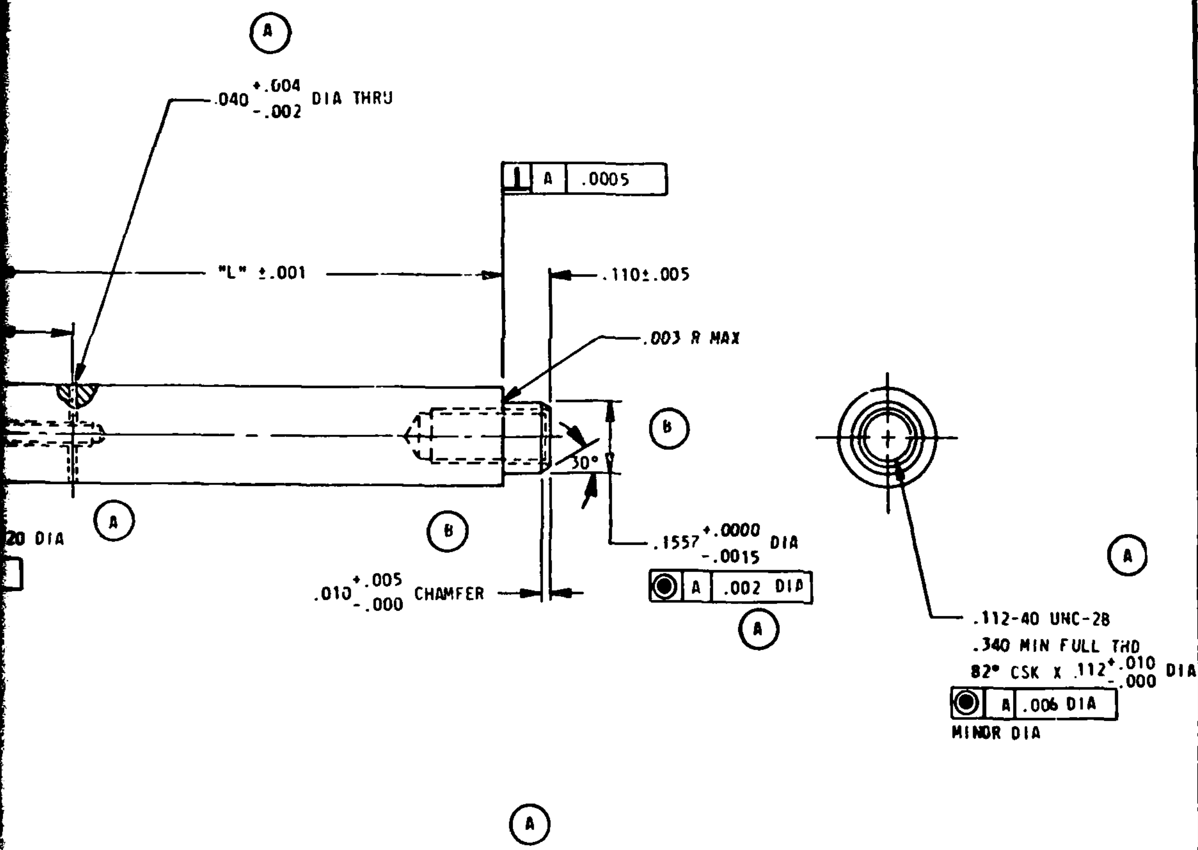
REV STATUS OF SHEETS					
5	4	3	2	1	SHEET NO
					REV LTR

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
	REIDENTIFIED - DRAWING NO WAS 3244188B		
	NAVSEA CHANGE CONTROL D 6/16/77	6-9-77	
A	SEE ECP PH1300-7 (CO 321309)	[illegible]	KD
B	SEE ECP PH1300-11 (CO 312397A) 2-... -80	[illegible]	KD

D

C



5188415

B

INTERPRET DRAWING IN ACCORDANCE WITH THE GENERAL REQUIREMENTS OF MIL-STD-100B

CONTR NO	N00024-76-C-7171
GENERAL DYNAMICS Pomona Division 99584 POMONA, CALIFORNIA 91766	
ENGR	3/18/77
PROD	
CHK	
PREP	11-3-76
CONTR APPROVAL	5-5-77
NAVSEA CHANGE CONTROL DATE 6-9-77	
MFG ENGRG	3/2/77

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C., 20362

PIN, CONNECTOR

A

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
.XXX = ± .010 ANGLES ± 2°
.XX = ± .03 FRACTIONS ±

IWS
IWS
IWS
IWS
USED ON
TION

MATERIAL:
BRASS ROD
ALLOY 360, 1/2 HARD
QQ-B-626

SIZE	CODE IDENT NO.	DRAWING NUMBER
C	53711	5188415

SCALE 4/1 | UNIT WT NA | SHEET 1 OF 1

223

058-900-024
X 'L' TABLE I

PBT&PBH

DATE OF RELEASE 5/13/77 D 6/16/77

PRECEDING PAGE BLANK-NOT FILMED

REV STATUS

5	4	3	2	1

NOTES:

1. REMOVE BURRS AND BREAK EDGES .010 MAX.
2. SURFACE TREATMENT: NONE; PARTS WILL BE TREATED AT NEXT ASSY.
3. SURFACE ROUGHNESS: 63√, EXCEPT AS NOTED.
4. DO NOT APPLY PART NO. TO PART, IDENTIFY WITH CODE IDENT, PART NO., DASH NO., AND REVISION LETTER IAW MIL-STD-130.

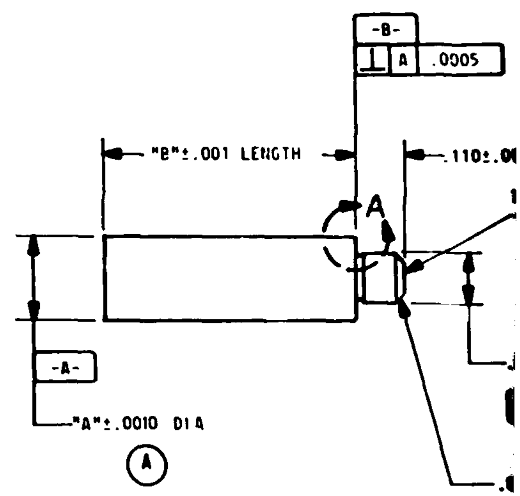


TABLE I

DIAMETER & LENGTH CHART

DASH NO.	"A" DIA	"B" LENGTH
-1	.1780	1.125
-2	.1840	1.125
-3	.1960	1.125
-4	.1500	.625
-5	.1830	.625
-6	.1900	.625
-7	.2000	.625
-8	.1500	.730
-9	.1800	.730
-10	.1870	.730
-11	.1910	.730
-12	.1930	.730
-13	.1940	.730
-14	.1950	.730
-15	.1690	1.300
-16	.1930	1.300
-17	.1950	1.300
-18	.1975	1.300
-19	.1990	1.300

INTERPR

NEXT ASSEMBLY	USED ON
5188420	CIWS

APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON
.XXX = ± .010 ANGLES ± 2°
.XX = ± .03 FRACTIONS ±

MATERIAL:
AL ALY BAR 6061-T6
IAW QQ-A-225/8

005-006-001

2 | 1 | 2

REV STATUS OF SHEETS					
5	4	3	2	1	SHEET NO.
					REV LTR

REVISIONS

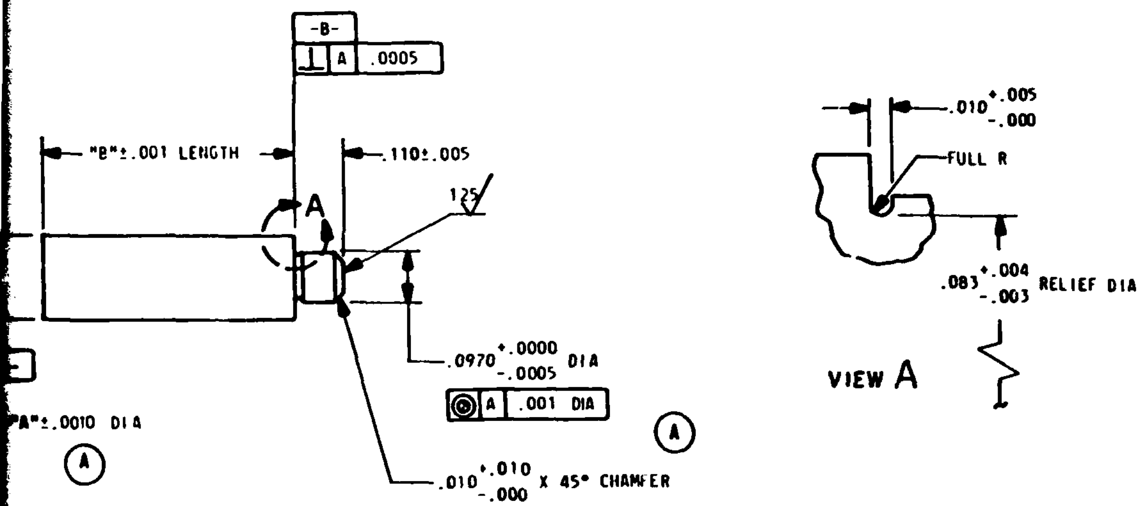
LTR	DESCRIPTION	DATE	APPROVED
	REIDENTIFIED - DRAWING NO WAS 3244181		
	NAVSEA CHANGE CONTROL 4/10/77	6-9-77	
A	SEE ECP PH1300-6 (CO 321352) 3 15 80	8-13-80	

D

C

B

A



5188409

INTERPRET DRAWING IN ACCORDANCE WITH THE GENERAL REQUIREMENTS OF MIL-STD-100B.

CONTR NO. N00017-74-C-4207

GENERAL DYNAMICS
Pomona Division 99584
POMONA, CALIFORNIA 91766

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, D.C., 20362

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES ON
.XXX = ± .010 ANGLES ± 2°
.XX = ± .03 FRACTIONS ±

ENGR 3/8/77
FPOD
CHK
PREP T. Causey 10-28-76

CIWS
USED ON
APPLICATION

PIN, FILTER

MATERIAL:
AL ALY BAR 6061-T6
IAW QQ-A-225/8

CONTR APPROVAL 6-5-7
NAVSEA CHANGE CONTROL
DATE 6-9-77

SIZE	CODE IDENT NO.	DRAWING NUMBER
C	53711	5188409

SCALE NONE | UNIT WT NA | SHEET 1 OF 1

223

↑ 005-006-001

MFG ENGRG 3/8/77

PBH & PBT

DATE OF RELEASE 6/11/77

PRECEDING PAGE BLANK-NOT FILMED

PARTS LIST

GENERAL DYNAMICS	DEPARTMENT OF THE NAVY	CONTRACT NUMBER	DRAWING CODE	REVISION CODE	ISSUE DATE
POMONA DIVISION 99584 POMONA, CA. 91766	NAVAL SEA SYSTEMS COMMAND WASHINGTON, DC 20362	N00024-76-C-7171	1. SPEC CONTROL DWG 2. SOURCE CONTROL DWG	1. ITEM ADDED 2. ITEM DELETED 3. QTY CHANGED 4. PART NO. CHG 5. MISC CORR	77/07/28 SHEET 1 OF 1

FSCM NO.		ITEM NOMENCLATURE	REV LTR	REV NUMBER	REV DATE
53711	PL 5188423	FILTER ASSY S13	A	CO 321306	4-7-80

FIND NO.	QTY REQD	NOMENCLATURE	FSCM NO.	IDENTIFICATION NUMBER	DOCUMENT NUMBER	REFERENCE DESIGNATOR	REMARKS AND CONTRACTOR USE ONLY	REV CODE	DWG CODE
1	1	COVER ASSY,S-13 FLTR		5188424					
2	1	HOUSING BODY		5188425-1					
3	2	HOUSING COVER		5188425-3					
4	13	SLUG,TUNING		5188507-2					
5	2	CONNECTOR		5188414-1					
6	2	CONNECTOR		5188414-3					
7	2	SCREW		MS16995-10					
8	16	SCREW		MS51957-2					
9	14	SCREW		MS51957-4					
10	2	CONNECTOR PIN		5188415-4					
11	30	WASHER		MS35338-134					
12	AR	ADHESIVE,EPOXY	10001	2622483				4,5	
13	AR	COATING			MIL-C-8514		597-800-064		
15	AR	PRIMER		CLASS 2	MIL-P-23377		597-800-062		
16	AR	SOLDER		SN60WRAP3	QQ-S-571		740-001-000		
17	AR	COATING		FED-STD-595 GRAY NO.26270	MIL-C-81773		597-800-061		
18	2	WASHER		NAS620C4					
19	2	WASHER		MS35338-135					
	REF	SOLDERING		MIL-STD-454					
	REF	IL OF TEST PRMTR		5186581					

PL 5188423

PARTS LIST

GENERAL DYNAMICS POMONA DIVISION 99504 POMONA, CA. 91766	DEPARTMENT OF THE NAVY NAVAL SEA SYSTEMS COMMAND WASHINGTON, DC 20362	CONTRACT NUMBER N00024-76-C-7171	DRAWING CODE 1. SPEC CONTROL DWG 2. SOURCE CONTROL DWG	REVISION CODE 1. ITEM ADDED 2. ITEM DELETED 3. QTY CHANGED 4. PART NO. CHG 5. MISC CORR	ISSUE DATE 77/06/15 SHEET 1 OF 1

FSCM NO.		ITEM NOMENCLATURE	REV LTR	REV NUMBER	REV DATE
53711	PL 5188 24	COVER ASSEMBLY,S-13 FILTER	A	CO 321392	2-9-80

FIND NO.	QTY REQD	NOMENCLATURE	FSCM NO.	IDENTIFICATION NUMBER	DOCUMENT NUMBER	REFERENCE DESIGNATOR	REMARKS AND CONTRACTOR USE ONLY	REV CODE	DWG CODE
1	1	COVER		5188425-2					
2	2	PIN FILTER		5188409-8					
3	2	PIN FILTER		5188409-9					
4	2	PIN FILTER		5188409-10					
5	2	PIN FILTER		5188409-11					
6	2	PIN FILTER		5188409-12					
7	2	PIN FILTER		5188409-13					
8	1	PIN FILTER		5188409-14					

PL 5188424

PARTS LIST

GENERAL DYNAMICS POMONA DIVISION 95584 POMONA, CA. 91766	DEPARTMENT OF THE NAVY NAVAL SEA SYSTEMS COMMAND WASHINGTON, DC 20362	CONTRACT NUMBER N00024-76-C-7171	DRAWING CODE 1. VENDOR SPEC. CONTROL 2. VENDOR SOURCE CONTROL 3. ASSEMBLY 4. SPEC. - PROC	REVISION CODE 1. ITEM ADDED 2. ITEM DELETED 3. QTY CHANGED 4. EDIT CORRECT	ISSUE DATE 77/06/15 SHEET 1 OF 1

CODE IDENT		ITEM NOMENCLATURE	REV LTR	REV NUMBER	REV DATE
53711	PL 5188425	HOUSING,S-13 FILTER	-		

FIND NO	QTY REQ	CODE IDENT	IDENTIFICATION NUMBER	NOMENCLATURE	DOCUMENT NUMBER	REFERENCE DESIGNATOR	REMARKS AND CONTRACTOR USE ONLY	REV CODE	DWG CODE
1	1		5188425-4	BODY	AL ALY PLATE QQ-A-250/11 6061-T6		505-018-061		
2	1		5188425-2	COVER	AL ALY SHEET QQ-A-250/11 6061-T6		505-018-049		
3	1		5188425-3	PLATE,END	AL ALY SHEET QQ-A-250/11 6061-T6		505-018-030		
4	2		MS16555-602	PIN					
5	AR		COLOR Y CHPSN L	PRIMER	TT-P-1757		597-005-001		

PL 5188425

DATE

ILME